New Scientist

WEEKLY October 31 - November 6, 2015

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SEEDS OF REVOLUTION

How civilization took root all over the world

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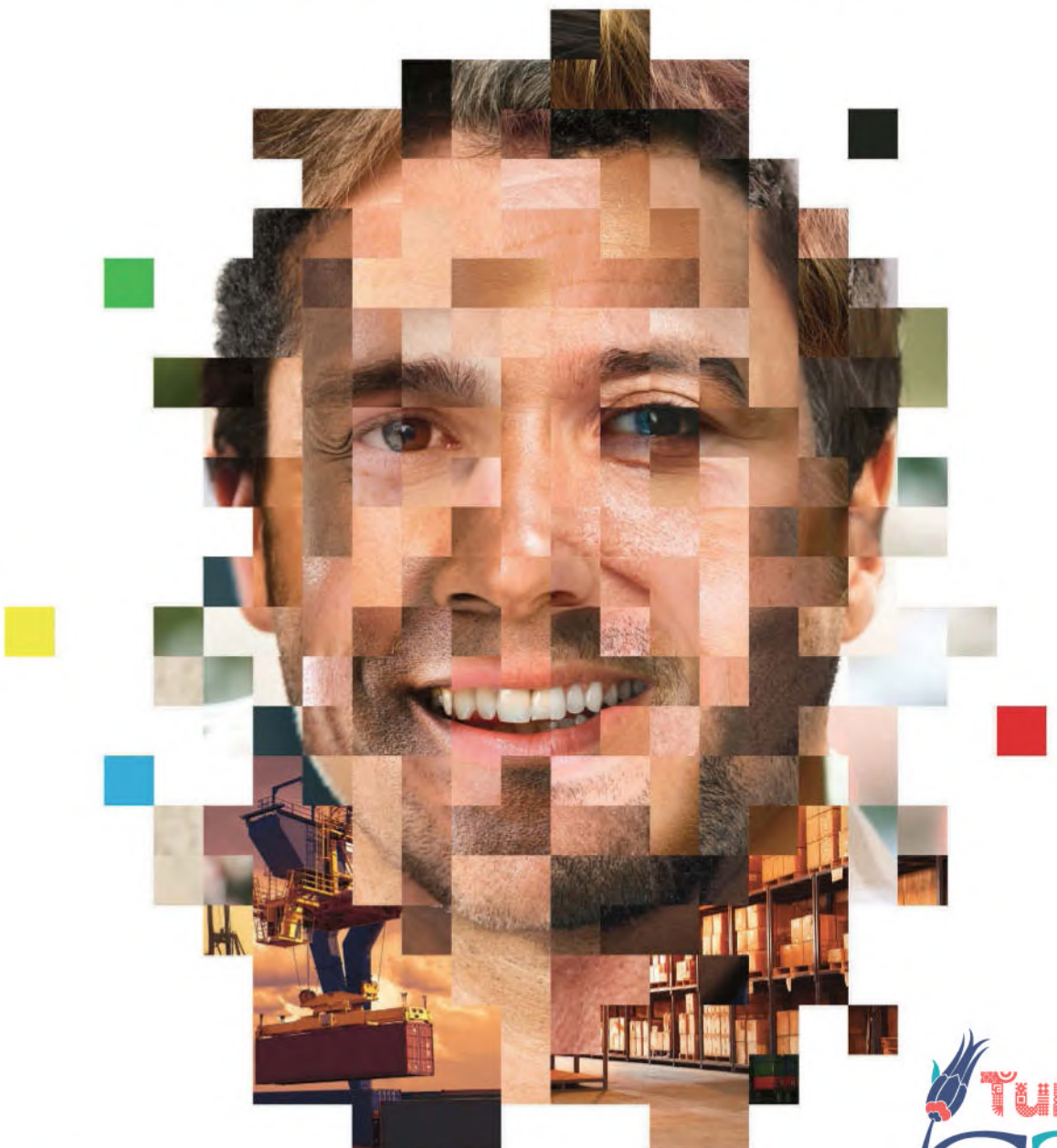

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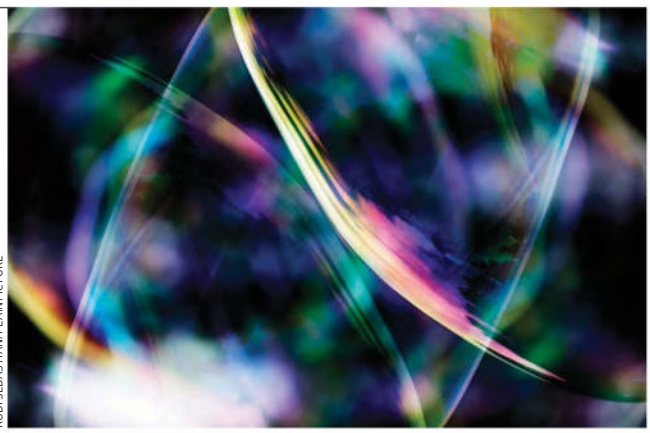

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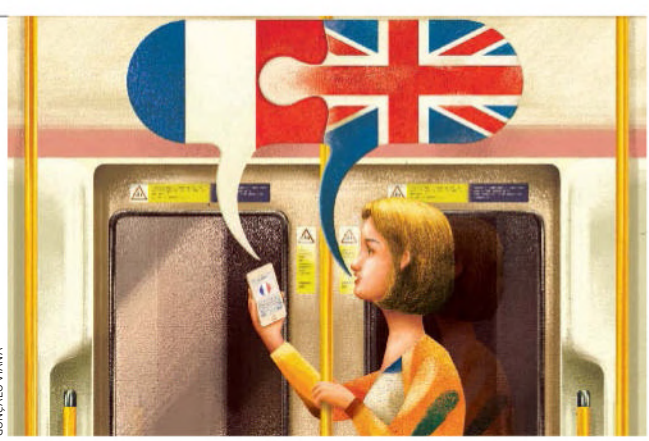

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General & media enquiries
enquiries@newscientist.com

Editorial
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news@newscientist.com
features@newscientist.com
opinion@newscientist.com

Picture desk
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KUNSTHISTORISCHES MUSEUM, VIENNA. ART MEDIA/GETTY

Deconstructing Babel

Tech is closing language gaps, with results we can't predict

WHY does humanity speak so many languages? Our ancestors decided it must be the result of divine intervention: when the people of Babel decided to build a tower to the heavens, God "confused" their tongues to scupper work on their hubristic project.

Today, we think languages "speciate" much as organisms do. Biological speciation is a complex process with many disparate triggers; languages, too, may split for reasons ranging from genetic mutations to changes in the environment. Some celebrate this diversity, but others wonder what humanity might achieve if united by a common language. In an obscure sequel to the biblical tale, Fénius Farsaid, legendary patriarch of the Irish people, directed 72 wise men to spend a decade studying Babel's confused tongues before reintegrating them into a single perfect language: Gaelic.

Gaelic has yet to catch on as a global *lingua franca*, but there are plenty of other candidates, most famously Esperanto, devised by Polish linguist Ludwik Zamenhof in the late 19th century. Although its fans claim that 2 million people have learned it, it cannot be said to have caught on: Klingon could, by some measures, be seen as much more successful.

Many constructed languages were created in the hope that a linguistically unified humanity would become socially unified, too. Another, Lojban, is designed on the basis of logic, enabling any person to communicate with any other without ambiguity – or perhaps even talk to a machine.

Talking to machines turns out to be key to demolishing language barriers, although not in the way Lojban's founders might have imagined. Smartphone apps, it seems, can sometimes succeed where correspondence courses and evening classes so often fail: in teaching adults a new language.

"You might not trust today's machine translation with literature or legal papers – but that day is coming"

This success is in part due to apps' tireless capacity for tuition, but it's also because their design is informed by an improved understanding of how adults learn – and how this differs from children's apparently effortless language acquisition (see page 40). Whether adult learners will share any of the cognitive benefits kids get from bilingualism (5 May 2012, p 30) remains to be seen.

But learning languages at all may fast be becoming passé. Five years ago, Google's question "Translate this page?" seemed more hopeful than helpful. But torrents of data have changed all that: the latest version of Android will translate typed messages on the fly. Audio is not far behind: Skype already offers real-time translation for some language pairs. You might not yet trust any of these with literature or legal papers – but that day is coming.

How such services will affect the evolution of language remains to be seen. Linguists are in despair at the rapid extinction of minority languages; could automated translation actually shelter them from competition with English or Mandarin? The internet has already helped far-flung speakers of rare tongues find each other. But the interplay of language and culture is complex, to say the least, and we should be wary of potential homogenisation.

Still, there are plenty of reasons to hope that automated translation will help humanity reach new heights. Fittingly, one such app was created to improve communication at CERN, a multinational consortium probing the secrets of creation. A better analogue to the tower of Babel is hard to imagine. And perhaps this time the story will end differently. ■

XINHUA NEWS AGENCY/REX SHUTTERSTOCK

Up to 1000 people may have died

Quake hits Afghanistan

A MAGNITUDE-7.5 quake that struck north-east Afghanistan on Monday has killed at least 311 people and injured 1500.

The final death toll could reach 1000, according to the US Geological Survey. "Communications appear to have gone down in the worst-affected areas, so it will be some time before we know the full impact," says Ilan Kelman of University College London.

The depth and nature of the quake means there should be fewer deaths than when an earthquake hit Nepal in April, killing 8000 people. As well as being a lower magnitude, the source of the Afghan quake was 200 kilometres below the surface, whereas the Nepal one was just 8 km down.

The great depth stems from the near-vertical dipping of slabs thought to be the remnants of a former subducting piece of Earth's crust that is burrowing beneath another piece, says Gavin Hayes of the USGS. "Deep quakes [in north-east Afghanistan] represent rupture within the core of the subducted 'slab'."

By contrast, the Nepal quake was on a much shallower and more active plate boundary and was related to the release of strain at a plate boundary. Such quakes have the potential to be much larger and more damaging than the deep slab events seen in Afghanistan, says Hayes.

Reaching and helping casualties could be tricky, says John McCloskey of the University of Ulster, UK. "In this region, the topography is very steep, so landslides are likely to pose a particular threat."

Climate sidetracked

SHOW us the money. Negotiators at last week's UN climate talks in Bonn, Germany, spent most of their time talking about finance.

By the end of the talks – the last before the showdown on a climate treaty expected at the UN climate summit in Paris in December – some 150 governments had made pledges to cut or moderate growth in their greenhouse gas emissions after 2020. Hold-outs included oil-producing Gulf states such as Saudi Arabia. But even so, analysts say the pledges put the world on a path to halt global warming at 2.7 °C – higher than the agreed safe rise of just 2 °C.

"No one is better placed to win big in the multi-trillion dollar low carbon energy future than the US"

Whether those voluntary pledges form part of a wider treaty now hangs on wrangling over money. Developing nations say their price for a deal is the fulfilment of promises from rich nations to stump up $100 billion a year by 2020 to help them limit their emissions and adapt to extreme weather. They expect government-to-government aid.

But the developed world says most of the money will be private-sector investment, especially in renewable energy. The US chief climate negotiator told the US Senate last week that "no one is better positioned to win big in the multi-trillion dollar 21st century market for low-carbon energy innovation than the United States." That's not what developing countries had in mind – and could halt a deal in Paris.

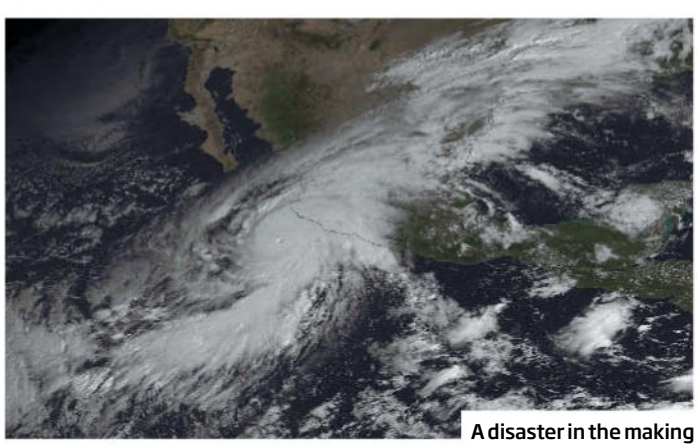
No let-up on TB

WE HAVE made great strides against tuberculosis, but much is still to do. Although infection rates are down, TB ranks alongside HIV as the leading cause of death from infectious disease.

This year marks the deadline for the Millennium Development Goal of cutting the number of TB cases globally, set in 2000 by the UN. The World Health Organization's annual report on the disease, out this week, says the goal has been reached. Even so, TB remains a major threat, killing 1.5 million people in 2014. The death toll for HIV was 1.2 million.

Last month, the UN set new global development targets – which include ending the global TB epidemic by 2030. This will be a massive challenge, requiring five times the current rate of decline in TB cases.

"[With] the lack of funding, and the fact you can count the number of good TB research facilities on one hand, I think the idea that we can get rid of this disease in a few decades is unlikely," says Ian Orme at Colorado State University in Fort Collins.



NASA/REX SHUTTERSTOCK

A disaster in the making

Patricia's close call

PHEW! Mexico had a close shave this week with the strongest hurricane ever to develop in the East Pacific. Patricia broke records, reaching wind speeds of 354 kilometres per hour and a pressure low of just 880 millibars.

It made landfall on the west coast, where a catastrophe was widely expected. But luckily this category 5 hurricane hit sparsely populated mountainous areas and quickly ran out of steam. Its

remnants brought more rain to the south-east US and contributed to flooding in Texas and along the Gulf coast.

The trigger for this monster is thought to be this year's strong El Niño. "There's a strong link between this event and El Niño," says Julian Heming, who works on predicting tropical cyclones for the UK's Met Office. "Ocean temperatures across the East Pacific have been well above average and atmospheric conditions have been conducive to the development of intense tropical cyclones."

More could be on the way.

Enceladus sampled

DRINK up. If all went to plan, we will have just got our best taste yet of the salty sea under Saturn's moon Enceladus.

On Wednesday, NASA's Cassini spacecraft was due to descend to within 49 kilometres of the surface, making its lowest pass ever through the plume of ice and vapour erupting from the moon.

Although the craft will have spent only tenths of a second within the plume, it should have been able to fingerprint simple organic molecules from the underground ocean. Its instruments can't detect life directly, but can measure levels of hydrogen in the plumes. That, in turn, should give us clues as to what conditions exist at potentially habitable vents on the sea floor.

On Earth, simple microbial ecosystems thrive in the warmth of hydrothermal vents, where they can produce energy by metabolising hydrogen released by the vents. Something similar could be occurring on Enceladus. "You could perhaps have very diverse kinds of life there," says Linda Spilker at the Jet Propulsion Lab in Pasadena, California.

Genetic test is back

WHAT are the odds of that? 23andMe is relaunching its direct-to-consumer genetic tests – now with official approval.

In 2013, the company was banned from selling a genetic test kit that provided customers with information about their risk of developing 254 conditions, including breast cancer and heart disease. The US Food and Drug Administration (FDA) said the company hadn't proved that it had clinically validated its tests for their intended uses.

Last week, 23andMe announced that it will resume selling a genetic health testing kit, for a smaller number of diseases. Each test has been FDA approved.

The kit, which costs $199, will provide customers with data based on "carrier information" about genetic mutations that could lead to diseases – such as cystic fibrosis – in offspring.

One concern about the previous kit was that the results didn't reflect the effect of environmental influences on many of the diseases. Such effects don't tend to matter for the conditions included in the new test package.

The company is, for now, refraining from testing for high-risk genetic mutations related to breast cancer or Alzheimer's.

Lion king's Africa rule in jeopardy

IS THE lion king being dethroned? Almost all large populations in West and Central Africa are declining, and may halve within 20 years. The situation is similar in East Africa.

But there is a glimmer of hope: lion populations in southern Africa are stable or increasing. This means it might be possible to reverse the overall downward trend, says Hans Bauer of the University of Oxford's Wildlife Conservation Research Unit.

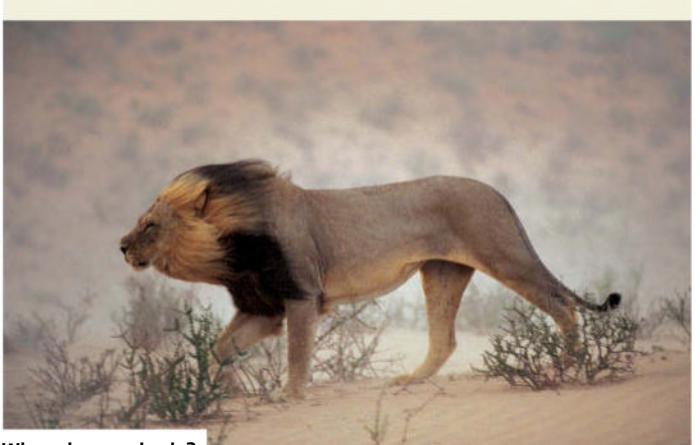
Bauer and his colleagues analysed existing information on populations across Africa, identifying declines in much of the continent. They then used this to model future trends (*PNAS*, doi.org/8qr).

Estimates suggest there are about 20,000 lions left in the wild – down from more than 200,000 a century ago. The main reasons for the decline are habitat loss, the depletion of prey through hunting, and conflict with people who perceive lions as a threat to their livestock, says Bauer.

But in Botswana, Namibia, South Africa and Zimbabwe, where most lions live in fenced reserves that are heavily managed, lion populations have been growing.

Bauer believes that such artificial management should be combined with more traditional conservation efforts to ensure lion survival in a more natural environment.

"We know what we need to do to save the lions," Bauer says, but there is a lack of resources and political will. "What we need is implementation."



CHRIS JOHNS/NATIONAL GEOGRAPHIC CREATIVE

Where is everybody?

60 SECONDS

Mission beyond Pluto

Engage thrusters! NASA's New Horizons spacecraft, which flew by Pluto this year, is now manoeuvring towards its next target. The probe is lining up to reach 2014 MU69, a small Kuiper belt object beyond Pluto, in 2019, but the spacecraft team still needs funding to ensure it gets there.

Defying death

It's a good time to be alive. Between 1969 and 2013, death rates in the US have fallen by 43 per cent, to 730 deaths per 100,000 citizens a year. Deaths from stroke or heart attack have plummeted by 77 and 68 per cent, which could be down to reduced smoking and better blood pressure control (*JAMA*, DOI: 10.1001/jama.2015.12319).

Superhot Hajj

Will the Hajj pilgrimage be a victim of global warming? Parts of the Middle East, including the Muslim holy places around Mecca, could become uninhabitable even for the young and fit before the century is out, according to the latest climate modelling (*Nature Climate Change*, doi.org/8qs).

Home for longer

A drug usually given to people with mild to moderate Alzheimer's disease could allow people in the more advanced stages to live in their homes for longer. A study of 295 people found that taking donepezil made a person half as likely to move into a care home within the next year. But the effect fell away in subsequent years (*The Lancet Neurology*, doi.org/8qq).

Dung shortage hits

Extinctions and the decline of large mammal populations have deprived Earth's ecosystems of fertilisation from their dung and decomposing bodies. Without their travels across vast distances, the capacity to spread nutrients around the globe has plummeted to 6 per cent of its former level (*PNAS*, doi.org/8qv).

A brush with a universe next door

Could cosmic bright spots reveal the multiverse, asks **Joshua Sokol**

THE curtain at the edge of the universe may be rippling, hinting that there's more backstage. Data from the European Space Agency's Planck telescope could be giving us our first glimpse of another universe, with different physics, bumping up against our own.

That's the tentative conclusion of an analysis by Ranga-Ram Chary, a researcher at Planck's US data centre in California. Armed with Planck's painstaking map of the cosmic microwave background (CMB) – light lingering from the hot, soupy state of the early universe – Chary revealed an eerie glow that could be due to matter from a neighbouring universe leaking into ours.

"If two bubbles started out close enough that they touched, they could leave an imprint on each other"

This sort of collision should be possible, according to modern cosmological theories that suggest the universe we see is just one bubble among many. Such a multiverse may be a consequence of cosmic inflation, the widely accepted idea that the early universe expanded exponentially in the slimmest fraction of a second after the big bang.

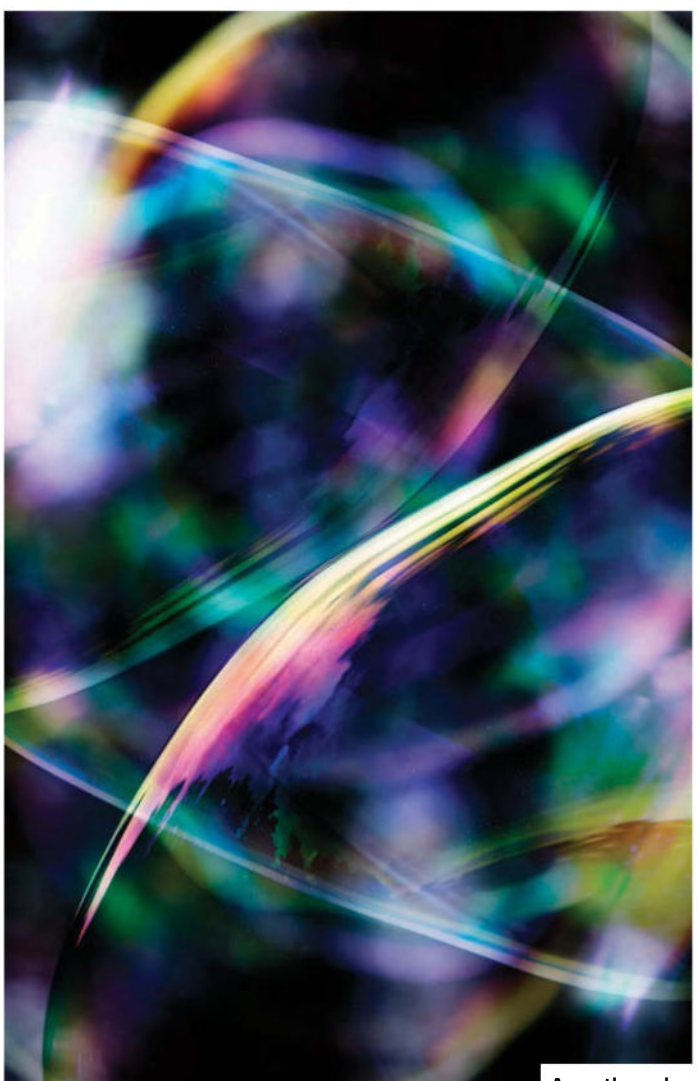
Once it starts, inflation never quite stops, so a multitude of universes becomes nearly inevitable. "I would say most versions of inflation in fact lead to eternal inflation, producing a number of pocket universes," says Alan Guth of the Massachusetts Institute of Technology, an architect of the theory.

Energy hidden in empty space drives inflation, and the amount that's around could vary from place to place, so some regions would eventually settle down and stop expanding at such a manic pace. But the spots where inflation is going gangbusters would spawn inflating universes. And even areas within these new bubbles could balloon into pocket universes themselves.

Like compositions on the same theme, each universe produced this way would be likely to have its own spin on physics. The matter in some bubbles – the boring ones – would fly apart within 10^{-40} seconds of their creation. Others would be full of particles and rules similar to ours, or even exactly like ours. In the multiverse of eternal inflation, everything that can happen has happened – and will probably happen again.

That notion could explain why the physical constants of our universe seem to be so exquisitely tuned to allow for galaxies, stars, planets and life (see "Just right for life?", right).

Sadly, if they do exist, other bubbles are nigh on impossible to learn about. With the space between them and us always expanding, light is too slow to carry any information between different regions. "They could never even know about each other's existence," says Matthew Johnson of York University in Toronto, Canada. "It sounds like a fun idea but it seems like there's no way to test it."



RUDI SEBASTIAN/PLAINPICTURE

A gentle nudge

Bubble trouble

However, if two bubbles started out close enough that they touched before expanding space pushed them apart forever, they could leave an imprint on each other. "You need to get lucky," Johnson says.

In 2007, Johnson and his PhD adviser proposed that these clashing bubbles might show up as circular bruises on the CMB. They were looking for cosmic dance partners that resembled our own universe, but with more of everything. That would make a collision appear as a bright, hot ring of photons.

By 2011, they were able to search for them in data from NASA's WMAP probe, the precursor to Planck. But they came up empty-handed.

Now Chary thinks he may have spotted a different signature of a clash with a foreign universe.

"There are two approaches, looking for different classes of pocket universes," Johnson says. "They're hunting for lions, and we're hunting for polar bears."

Instead of looking at the CMB itself, Chary subtracted a model

of the CMB from Planck's picture of the entire sky. Then he took away everything else, too: the stars, gas and dust.

With our universe scrubbed away, nothing should be left except noise. But in a certain frequency range, scattered patches on the sky look far brighter than they should. If they check out, these anomalous clumps could be caused by cosmic fist-bumps: our universe colliding with another part of the multiverse (arxiv.org/abs/1510.00126).

These patches look like they come from the era a few hundred thousand years after the big bang when electrons and protons first joined forces to create hydrogen, which emits light in a limited range of colours. We can see signs of that era, called recombination, in the light from that early hydrogen. Studying the light from recombination could be a unique signature of the matter in our universe – and potentially distinguish signs from beyond.

"This signal is one of the fingerprints of our own universe," says Jens Chluba of the University of Cambridge. "Other universes should leave a different mark."

Since this light is normally drowned out by the glow of the cosmic microwave background, recombination should have been tough for even Planck to spot.

"This signal is one of the fingerprints of our own universe. Others should leave a different mark"

But Chary's analysis revealed spots that were 4500 times as bright as theory predicts.

One exciting explanation for this is if a surplus of protons and electrons – or something a lot like them – got dumped in at the point of contact with another universe, making the light from recombination a lot brighter. Chary's patches require the universe at the other end of the collision to have roughly 1000 times as many such particles as ours.

"To explain the signals that Dr Chary found with the cosmological recombination radiation, one needs a large enhancement in the number of [other particles] relative to photons," Chluba says. "In the realm of alternative universes, this is entirely possible."

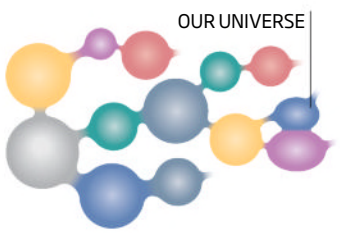
Of course there are caveats, and recent history provides an important reality check. In 2014, a team using the BICEP2 telescope at the South Pole announced another faint signal with earth-shaking cosmological implications. The spirals of polarised light, spotted in the cosmic background, would have provided more observational evidence for the idea of inflation and helped us understand how inflation occurred. But it turned out that signal came from dust grains within our galaxy.

Princeton University's David Spergel, who played a major role in debunking the BICEP2 finding, thinks dust may again be clouding our cosmological insights. "I suspect that it would be worth looking into alternative possibilities," he says. "The dust properties are more complicated than we have been assuming, and I think that this is a more plausible explanation."

Joseph Silk of Johns Hopkins University in Baltimore, Maryland, is even more pessimistic, calling claims of an alternate universe "completely implausible". While he thinks the paper is a good analysis of anomalies in Planck data, Silk also believes something is getting in the way. "My view is that they are almost certainly due to foregrounds," he says.

Eternal inflation

Our universe could be one of many bubble universes in a branching, ever-expanding multiverse. If we bump up against another universe, it could leave a mark on the ancient sky



Chary acknowledges that his idea is as tentative as it is exciting. "Unusual claims like evidence for alternate universes require a very high burden of proof," he writes.

He makes an effort to rule out more prosaic explanations. If it is dust, Chary argues, it would be the coldest dust we've ever seen. It's probably not noise masquerading as a signal. It could be carbon monoxide moving toward us, but we don't usually see that. It could be faraway carbon, but that emission is too weak.

"I am certain he made every effort to ensure that the analysis is solid," says Chluba. Even so, foregrounds and poorly understood patterns could still be the source of the signals. "It will be important to carry out an independent analysis and confirm his finding," Chluba says.

Sensitive solutions

One obstacle to checking is that we're limited by the data itself. Planck was hyper-sensitive to the cosmic microwave background, but it wasn't intended to measure the spectral distortions Chary is looking for. Johnson's team also plans to use Planck to look for their own alternate universes, once the data they need is released to the public – but they estimate that Planck will only make them twice as sensitive to the bubble collisions they're looking for as they were with WMAP.

An experiment that could help might be on its way. Scientists at NASA's Goddard Space Flight Center plan to submit PIXIE, the Primordial Inflation Explorer, to be considered for funding at the end of 2016.

PIXIE's spectral resolution could help characterise Chary's signals if they really are there, Chluba says. But even if they aren't, reconstructing how inflation happened could still lead us once again back to the multiverse – and tell us what kind of bubble collisions we should look for next. ■

JUST RIGHT FOR LIFE?

If our universe is just one of many, that could explain why it seems so exquisitely tuned for our existence.

If dark energy, the repulsive influence hiding in empty space that speeds up the expansion of the universe, were just a little stronger, matter would be flung apart before galaxies could ever form. If it were attractive instead, the universe would collapse. But it is shockingly puny, and that's weird, unless our universe is one of many in the multiverse.

Compared with what we might expect from quantum theory, dark energy is 120 orders of magnitude too small. So far, no compelling explanation for that discrepancy has emerged. But if the multiverse exists, and dark energy varies from bubble to bubble (see main story), that might not seem so strange.

That's because our own universe might be an oddball compared to most bubbles. In many, dark energy would be too strong for galaxies, stars and planets to form, but not in all. "Plenty of them would have energies as small as what we observe," says physicist Alan Guth of MIT.

That still leaves us struggling to explain why our universe is one of the special ones. Our best answer so far, Guth says, is a philosophical headache: our universe has to be special because we are alive in it. In a more average region, where dark energy is stronger, stars, planets, and life would never have evolved.

That could mean life only exists in a sliver of the multiverse, with any conscious beings convinced their own slice of space is special, too.

REUTERS/DAVID PARRY

Never been part of a cow

Meat without murder?

We had the first lab-grown burger. Now a bioreactor for growing artificial meat on a large scale is about to be built

Hal Hodson, Maastricht, the Netherlands

DEEP in the industrial heartland of the Netherlands, far from any cows, the future of meat is taking shape. This time next year, a 5000-litre bioreactor could be up and running with the goal of eventually growing enough synthetic flesh to provide 2000 people with their annual meat ration.

This is the vision of Mosa Meat, launched last week by Mark Post, whose lab-grown beefburger was cooked and eaten on live television in 2013.

The launch coincided with the first-ever symposium on cultured meat, held in Maastricht. Around 100 scientists met to discuss the promise and pitfalls of meat made without animals. Tissue engineers presented new ways to grow flesh, social scientists discussed its public acceptance, and biological engineers highlighted the vast scale needed to produce the stuff in useful amounts.

Trying to grow meat in a vat, rather than raising and killing animals, makes sense if we want to continue eating it in large quantities while preventing further damage to the environment – and maximising animal welfare. A 2006 report from the UN Food and Agriculture Organization paints a clear picture: livestock farming is one of the "most serious environmental problems, at every scale from local to global". Beef is the worst offender: producing 1 kilogram uses 15,000 litres of water and sends 300 kilograms of carbon dioxide into the atmosphere.

According to a 2011 analysis by Hanna Tuomisto at the University of Oxford, cultured meat would produce far fewer greenhouse gas emissions, and use much less water and land (see chart, right).

"We want to end up with a 25,000-litre bioreactor, enough to feed vat meat to 10,000 people a year"

So could we get to a point where synthetic meat replaces farm animals? In essence, the process is simple. Take stem cells from animals (see "Will vat meat ever replace animals?", above right), feed them and allow them to divide and grow into a big chunk of muscle cells. There are several key challenges in this, however, one of which was spelled out by meeting attendee Chris Hewitt, a biological engineer at Aston University in Birmingham, UK. Unlike most bioengineering on the planet today, he points out,

culturing meat means growing cells as a product, not using them to make something else.

Bioreactors typically use cells to produce useful proteins, then discard the cells. For example, the breast cancer treatment herceptin is made using genetically modified hamster ovary cells in gigantic 25,000-litre vats. Human insulin comes from modified *E. coli* bacteria and the statins used to treat heart disease, are made in yeast cells. "I've spent my career growing cells in tanks," Hewitt says. "It's very rare that the cell is the basis of the product."

The difficulty is keeping them alive – making sure they have a constant supply of oxygen and food. Growing a giant blob of cells doesn't work, as the cells in the centre die for lack of oxygen.

Plastic beads

One way to get around this is to grow the cells on a surface of tiny plastic beads that facilitates the flow of oxygen and nutrients. Companies like Janssen in the US do this in vats with a capacity of up to 1000 litres, but it is a relatively expensive and complicated process.

Because of this, producers have now figured out ways to adapt the cells to operate in a suspension. Floating free in a vat allows cells to be grown at much higher densities and in greater quantity.

But Post's business partner Peter Verstrate points out that getting a 5000-litre bioreactor up and running does not mean Mosa will be producing edible artificial meat right away.

Like all cell cultures, the meat cells rely on a feedstock containing nutrients and growth hormones. For cultured beef, this means including 5 per cent bovine fetal serum. This is a substance derived from blood collected from the heart of an unborn calf after its mother is slaughtered. It is a "by-product" of the dairy industry, in the sense that dairy cows are routinely disposed of after a certain number of years, but it negates for the time being any potential environmental or ethical advantages to be gained from cultured meat. Post hopes to eliminate the need for this in the long run.

The rest of the nutritious goop fed to the cell culture is ethically unobjectionable, but is nevertheless expensive, appropriate for the relatively small scale needed for medical cultures but not for food production on an industrial scale.

Nor will Mosa's final product bear much resemblance to actual meat. What comes out of the vat is a collection of muscle cells, white until coloured by beetroot and lacking in the real-meat flavours provided by blood and fat.

Post hopes to find solutions to these problems as they go along. "We want to end up with a 25,000 litre bioreactor – enough to provide meat for 10,000 people a year, at European consumption levels," he says.

Still, even this ambitious target is nothing compared with the scale required to make any kind of dent in global meat consumption. Hewitt and his colleague Qasim Rafiq estimate that total bioreactor space available on the planet at the moment amounts to, at most, 1 million litres. If all this space was turned over to cultured meat production, it would provide meat for just 400,000 people.

So we will need to dramatically improve the efficiency of the cultured-meat producing process, not to mention building a lot more steel vats.

This scale means alternative solutions are likely to win in the short run. For example, rather than muscle cells, it may make more sense to focus on producing synthetic versions of the things that make meat delicious – blood and fat – to flavour non-animal-derived protein.

David Zilber, a chef at Michelin-starred Norwegian restaurant Noma who attended the meeting, says that meat is more of a concept than a specific substance, defined by taste, smell and texture rather than any one source. After two days listening to tissue engineers and food scientists detail their struggle to produce anything that resembles real meat, Zilber concludes that a bioengineered meat broth might be a more useful first product to aim for, perhaps to accompany ramen noodles. And other vat-derived components could help push non-animal protein sources such as soya over the edge into meatiness.

Verstrate agrees that focusing on particular characteristics, and bioengineering for flavour, rather than structure and calories, may have merit. "I do see this Lego approach emerging in the future," he says.

Meanwhile, the market for meat substitutes is taking shape, with multiple start-ups, mostly in the US, coming onto the scene. Los Angeles-based Beyond Meat uses pea protein to mimic meat structure, for example, and Impossible Foods in Redwood City in California, is developing a mixture of plant-derived proteins to make meat-like patties. Dutch company Beeter and British firm Quorn both have sizeable market shares in imitation meat.

"The meat cells rely on a feedstock containing bovine fetal serum, derived from slaughtered cattle"

"There's an ecosystem building to make animal products without animals," says Isha Datar, CEO of New Harvest, a non-profit which advocates and raises funds for animal alternatives.

Along with growing muscle, Post's lab at Maastricht University has now started work on synthesising fat from stem cells. And if the chef's word is anything to go by, that could be where the big advances are made. "Blood and fat is what makes meat," says Zilber. "Muscle is just the vehicle." ■

WILL VAT MEAT EVER REPLACE ANIMALS?

If we work out how to make artificial meat on a global scale, what would the world look like? Will farm animals simply disappear?

The transition will not be a sudden one, but even then domesticated livestock will be needed. They will be valued for the stem cells that are the foundation of meat cultures. "Adult stem cells have a limited lifetime," says Post. "You need to keep a donor herd."

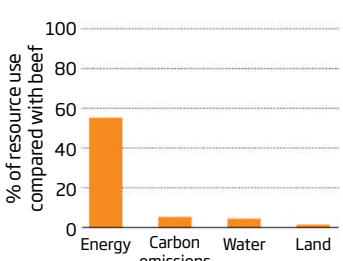
This means that producers will need to keep returning to live herds for stem cells, which can be taken without harming the animal. Future herds might become semi-wild, only tracked down when it's time for a new batch of cells.

Cell cultures currently rely on fetal serum taken from the appropriate species. But even if no alternative is found, livestock would be far fewer in number, and with no need for intensive farming there would be an end to the most environmentally destructive, high-density feedlots.

David Zilber, a chef at Danish restaurant Noma, says that in a world where artificial meat is mainstream, there would be a market for high-quality real meat, produced in a way that is as ethically and environmentally friendly as possible.

Artificial but greener

Estimates of lab-grown meat's environmental impacts suggest it would only use a fraction of the resources needed to produce beef



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Rosetta's comet is first with oxygen

#ROSETTAWATCH

IF THE comet lander Philae were alive, it might be able to breathe. The Rosetta spacecraft has discovered oxygen in 67P Churyumov-Gerasimenko's atmosphere – and the team thinks it may date back to the birth of the solar system, when comets and planets first formed.

Molecular oxygen – the kind we breathe – has never been seen on a comet before. Oxygen is a volatile chemical that shouldn't stick around for long in space, and the team couldn't be sure that it wasn't coming from the spacecraft itself. But after seven months of observing, they were confident that the oxygen had been buried in the comet since its birth about 4.5 billion years ago (*Nature*, DOI: 10.1038/nature15707).

Oxygen levels stayed high from September 2014 to March 2015, even while the comet's upper few centimetres hissed away into space. That rules out chemical reactions between ice and sunlight, which would only have happened in the comet's outermost skin, and hence would have declined as this layer disintegrated.

The oxygen levels also varied in step with water levels as Rosetta flew around the comet, suggesting that ice and oxygen in 67P's atmosphere are coming from the same places in its nucleus. That could help solve a mystery about when oxygen first appeared in the solar system.

"This goes to the core of the question of whether this primitive solar system material was made in the interstellar medium, or whether it was made in the solar nebula later," says Klaus Pontoppidan of the Space Telescope Science Institute in Maryland.

Astronomers have long searched for oxygen in the kinds of interstellar clouds where we think solar systems are born, but without much luck. So how did 67P come to have oxygen?

Andre Bieler of the University of Michigan and his team have two theories. In one scenario, interstellar clouds contain tricky-to-see oxygen gas, which got caught up as the cloud collapsed into a disc, then flash-froze and stuck to tiny grains of ice. But the more likely explanation, they think, is that the oxygen was chemically made later – inside ice grains in the disc, where it stayed trapped for eons.

Either theory would require that when grains combined into pebbles, boulders and eventually the comet, they never got too hot or pressurised. "The whole accretion of these icy grains has to be pretty gentle," Bieler says.

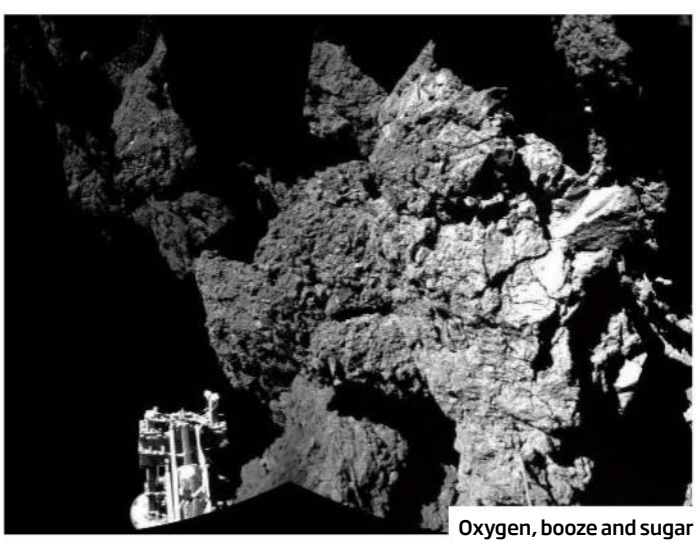
Recent models of 67P's formation agree with the idea that the comet's birth was relatively calm. The fusion of its two lobes seems to have been a peaceful affair, not a dramatic collision.

That's not the only comet chemistry in the news this week. In another study, researchers observing comet Lovejoy, which veered closest to the sun in January, spotted alcohol and simple sugars in its atmosphere – another first for comets (*Science Advances*, DOI: 10.1126/sciadv.1500863). The Rosetta team says 67P hosts similar stuff.

If other comets have oxygen, this glimpse into the early solar system's chemistry could help us piece together a record of conditions on early Earth, too.

"It's linked to how well we know the composition of the planets early on, especially with regards to habitability," Pontoppidan says. "It changes how we may understand the conditions for life."

Joshua Sokol and Sam Wong ■



ESA

Oxygen, booze and sugar

Anaesthesia dulls emotional memories

ANAESTHETICS do more than numb pain, they also blunt memories.

In 2014, a small study showed that after coming round, people found it difficult to remember the emotional content of memories they recalled just before they were given an anaesthetic. But the people in this study were undergoing electroconvulsive therapy to their brain, so it wasn't clear whether it was the anaesthetic or the therapy causing the change in memory.

To find out, Bryan Strange at the Technical University of Madrid, Spain, recruited 40 people having an endoscopy under general anaesthetic. Participants first watched two narrated slide shows that each told a story made up of three parts – with the middle part containing some negative emotional content. A week later, and minutes before being given an anaesthetic, each volunteer was reminded of one of the stories by showing them the first slide.

Half were asked to recall the story as soon as they came round, the others 24 hours later. Those tested on the spot could remember the whole story, but after 24 hours the others found it much harder to remember the emotional middle than the mundane beginning or end. They remembered all three parts of the other story.

Reconsolidation is thought to be a process in which a memory becomes more malleable for about 24 hours after we're reminded of it. Strange's study suggests that interrupting reconsolidation might cause the most emotional aspects to fade.

"Perhaps interrupting the reconsolidation of a memory causes some aspects of it to fade"

Strange thinks this could help people with PTSD or depression forget painful memories. But, he says, there is no need to panic before surgery about accidentally erasing memories: "The effect might be transient and we need to look at whether it works in real-life memories first." He presented the work at the Neuroscience 2015 conference in Chicago this week.

Catherine de Lange ■

Self-sacrificing immune cells spew DNA net

AS WELL as carrying the instructions for how to build you, it turns out DNA makes a handy weapon. As a last-ditch defence against invading microbes, immune cells spew out sticky nets of their DNA.

"DNA is so physically packed that when you uncoil it you get a huge net," says Donald Sheppard of McGill University in Montreal, Canada. "It's like one of those cans of exploding snakes, only a thousand times more dramatic."

Normally, immune cells called neutrophils kill microbes by gobbling them up or releasing toxic chemicals. But recently it was found that when all else fails, they disgorge nets of DNA studded with antimicrobial compounds, destroying themselves in the process. The nets can span small blood vessels, ensnaring and killing bacteria.

Now Sheppard's team has shown that neutrophils also use this tactic against fungal infections in the lungs (*PLoS Pathogens*, doi.org/8qx). *Aspergillus* usually infects people with weakened lungs or immune systems, and is too big for a neutrophil to ingest, so the immune cells use their nets to deliver a concentrated dose of toxins.

But one virulent strain of *Aspergillus* seems to evade destruction. Work in mice suggests that this strain has acquired a sugary coating that repels the nets, so Sheppard's team is developing drugs against this coating.

The neutrophil nets have a downside, however: they may trap any cancerous cells circulating in the bloodstream, helping them spread into nearby tissues and seeding the growth of secondary tumours.

"It's a double-edged sword," says Lorenzo Ferri, also at McGill University. He has shown that when mice with a version of lung cancer are given drugs that dissolve the nets, they develop fewer secondary tumours.

Clare Wilson ■

BEE VECTORING TECHNOLOGY

Another job? Quit pollen my leg

Bees put to work lugging pesticides to flowers

THEY'RE not called worker bees for nothing. Bumblebees buzz from plant to plant collecting food, and plans are afoot to give them another task while they do it – carrying pesticides to where they are needed. Bee Vectoring Technologies (BVT) in Mississauga, Canada, has opened a commercial production plant this month in the hope that the tactic will lure farmers away from indiscriminate crop spraying.

The idea involves placing a tray of organic pesticide powder inside a commercially bred hive. The powder contains a substance to help it stick to bees' legs and a strain of *Clonostachys rosea* fungus that is harmless to these insects but attacks crop diseases and pests. "It's a perfectly natural fungus found very commonly throughout the world. We've just developed a way to grow and harvest it efficiently," says Michael Collinson, CEO of BVT.

The bumblebees walk through the powder as they leave the hive. When they land on flowers to gather nectar and pollen, they leave a dusting of pesticide to protect the plant and future fruit.

Many crops can be protected this way, including blueberries and bell peppers. BVT plans to provide its dispensing system to a number of companies that have developed biological controls for other pests such as fireblight, which affects apples and pears.

"These bees fly for us, delivering pesticides to targeted crops. It's better for the environment"

"Farmers usually spray the whole orchard and 99 per cent of it ends up in the wrong place," says Collinson. "We can deliver it locally and use 20 grams as opposed to 2 kilograms. It's much better for the environment."

David Passafiume, an organic farmer near Toronto, has been using the system for five years on 8.5 acres of strawberries and raspberries. "We were losing a significant portion of our crop each year to *Botrytis* and tarnished plant bugs," he says. Now those losses are negligible and profits have gone up by a quarter, he says. "I wouldn't even try to grow without it now."

The idea of using bees to carry pesticides isn't new, but BVT is one of the first to attempt to commercialise the approach.

"It's a good idea. It's better than spraying highly toxic chemicals over acres of land," says Don Steinkraus, an entomologist at the University of Arkansas in Fayetteville. "As long as it doesn't have a bad effect on the bees."

Jeremy Kerr, a biologist at the University of Ottawa in Canada, thinks it should only be used inside greenhouses, away from wild bees. If used outside, he says, it could have unintended effects on non-target plants or other pollinators.

Another concern relates to BVT's use of commercially bred insects. "Domesticated bumblebees carry pathogens that can be transmitted into the wild," says Sydney Cameron of the University of Illinois at Urbana-Champaign. "That issue has not been resolved."

The company plans to work with other companies to deliver inorganic pesticides that have been deemed safe to bees by the US Environment Protection Agency. But the agency typically tests only on honeybees, using them as surrogates for all pollinators, despite differences between bee species.

"Honeybees and bumblebees differ in their responses to pesticides in ways that can be hard to predict," says Dave Goulson at the University of Sussex in Brighton, UK. What's more, the EPA generally tests only to see if chemicals are acutely toxic, rather than looking at the effects of long-term exposure.

Collinson says the company is "very cautious" about the insects' well-being. "Our business is bees. We need these guys to fly for us."

His company now plans to add more biocontrols to its pesticide mix to create broad-spectrum crop protection. **Olivia Solon** ■

ANDREW ERRINGTON/GETTY

Time for a memory game

Brains rejuvenated by asthma drug

IT'S as good as new. An asthma drug has rejuvenated rat brains, making old rats perform as well as young ones in tests of memory and cognition.

Our brains slowly degenerate as we age. Typically, we lose the ability to make new neurons. And age-related inflammation of the brain is implicated in many brain disorders.

To tackle both problems in one go, Ludwig Aigner at Paracelsus Medical University Salzburg in Austria and his colleagues targeted a set of receptors in the brain that, when activated, trigger inflammation. These receptors are also thought to be involved in the birth of neurons.

A drug called montelukast (Singulair), regularly prescribed for asthma and allergic rhinitis, blocks these receptors, so Aigner and his colleagues tested it on young and old rats. The team used oral doses equivalent to those taken by people with asthma. The older animals were 20 months old – perhaps between 65 and 75 in human years. The younger rats were 4 months old – roughly the equivalent of 17 human years. The animals were fed the drug daily for six weeks, while another set of young and old rats were left untreated. There were 20 young and 14 old rats in total.

The rats took part in a range of learning and memory tests. One of these involved the rats being placed in a pool of water with a hidden escape platform. At the start of the study, untreated young rats learned to recognise landmarks and quickly find their way to the platform, while the untreated older animals struggled at the task.

By the end of their six-week drug regime, though, old animals performed as well as their younger companions. "We restored learning and memory 100 per cent, to a level comparable with youth," says Aigner. He presented his findings earlier this month at the Neuroscience 2015 meeting in Chicago.

Old rats that had been given montelukast had 80 per cent less brain inflammation than old rats that hadn't been given the drug. They also had greater new neuron growth than untreated old rats – about 50 per cent of that seen in young rats, says Aigner.

The team also found that the blood-brain barrier – which stops infectious agents reaching the brain but weakens with age – was stronger in treated old rats. "Structurally, the brain had rejuvenated," says Aigner.

The drug had no effect on young animals, probably because it targets inflammation associated with age, says Aigner. "We've identified a target that affects many different systems of the aged and degenerated brain," he says. "I think the drug reverses the damage associated with ageing."

Because montelukast is widely used, it should be relatively easy to look for similar effects in clinical trials in people, says James Nicoll, a neuropathologist at the University of Southampton, UK. Aigner agrees – he will start by testing the drug in people with Parkinson's disease, he says.

Jessica Hamzelou ■

Dark matter may send stars over the edge

EXPLODING stars may have dark fuses. The same mysterious stuff that holds galaxies together could also be responsible for blowing stars apart.

Once a star has exhausted its fuel, it will collapse under its own gravity. If a star started out with 1.4 times the mass of the sun or less, it will become a dense white dwarf, packing the mass of the sun into an Earth-sized volume. Any heavier than that, and it will explode as a supernova.

White dwarfs in turn only explode if they find a way to gain mass, which turns them into a variety of supernova called a type Ia. Astronomers thought white dwarfs gained mass from a companion star, but about half of the type Ia supernovae show no signs of a companion. Now Joseph Bramante at Northwestern University in Massachusetts says dark matter could provide the missing mass (*Physical Review Letters*, doi.org/8qb).

Dark matter makes up most of the mass in the universe but shuns contact with ordinary matter. Since it has mass and responds to gravity, it should pool inside the dense white dwarfs. Assuming that dark matter particles are fairly heavy and can interact with each other in some way, they could increase the white dwarf's density enough to make it explode.

To test whether this is really happening, Bramante suggests looking for type Ia supernovae in areas with lots of dark matter, the central region of a galaxy, say, and checking to see if their progenitor stars differ from what we expect.

"White dwarfs explode if they have a way to gain mass, which could be provided by dark matter"

Dejan Stojkovic of the State University of New York at Buffalo says the model sounds reasonable, but remains cautious. It depends on dark matter having specific properties, and nobody knows yet what kind of particles make up dark matter.

Dark matter isn't the only possible culprit: primordial black holes could occasionally hit lone white dwarfs, or white dwarfs could collide with each other. Jesse Emspak ■

THE BAFFLING, TRIVIAL, CURIOUS, OR STRANGE . . .

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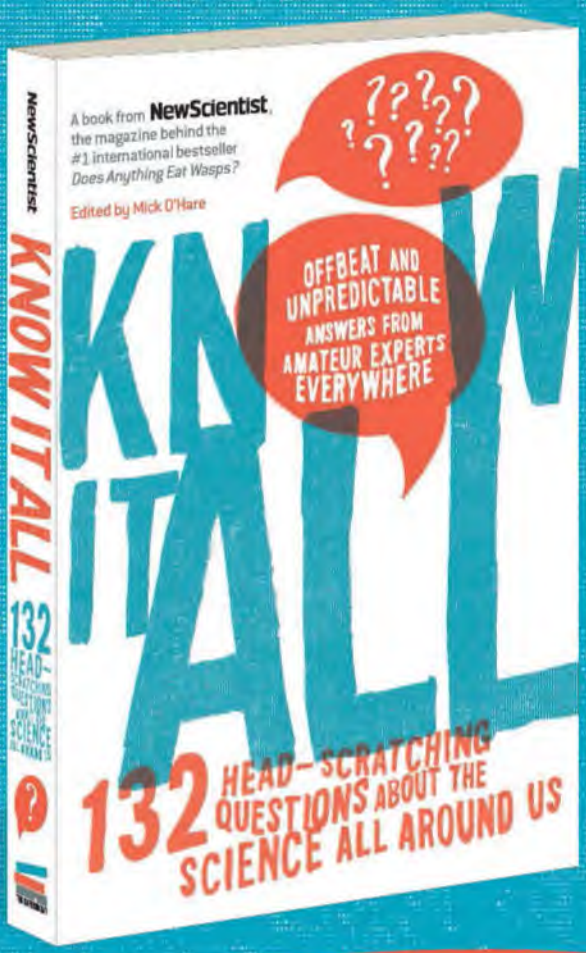

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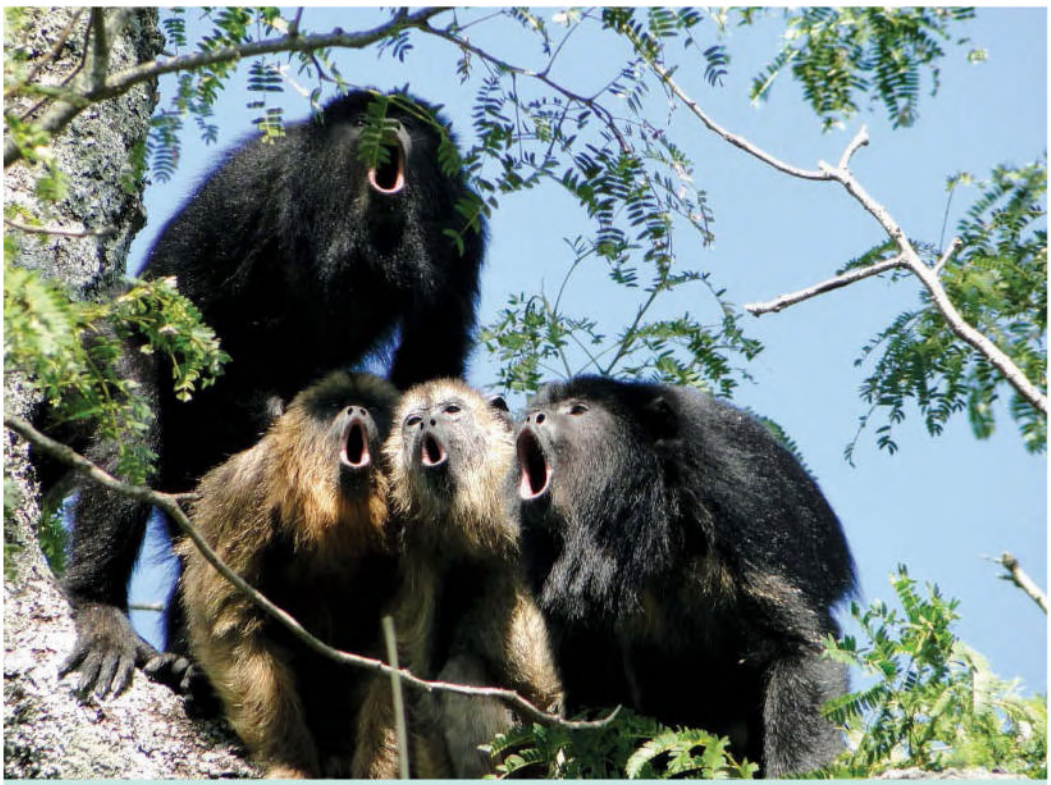
MARIANA RAÑO

It's all show: loudest howlers have the smallest testes

PERHAPS the quieter ones have nothing to prove.

Male howler monkeys are famed for their deep, powerful roars, which are among the loudest in the animal world. They call at frequencies as low as those used by tigers and reindeer, which are some 10 times larger. The calls may make the monkeys seem larger than they are, helping them impress mates and intimidate rivals. But what they gain in vocal ability, it seems they lose in testicle size.

Jacob Dunn at the University of Cambridge and his colleagues analysed the size of testes in nine species. They compared them with the size of the howler's hyoid bones, which are found in the neck and hold a sound-amplifying air sac. Larger hyoids meant smaller testes. And species that formed social groups containing proportionately more males tended to have smaller hyoid bones but larger testes (*Current Biology*, doi.org/8qg).

This suggests an evolutionary trade-off between the two: given limited resources, monkeys might have to choose whether to invest energy in roaring or making sperm to maximise their chances of reproducing successfully. Alternatively, big voiced-males might be better able to fend off other males, reducing competition for their sperm, and so not needing large testes. "There might well be an element of both," says Dunn.

Neighbouring planet could be an illusion

ALPHA Centauri Bb may be an ex-exoplanet. This long-sought world was announced in 2012 as the first Earth-mass planet in the nearest star system to our own, but statistical analysis has now revealed it to be an apparition.

The original discovery was made by Xavier Dumusque, then at the Geneva Observatory in Switzerland, and his colleagues. They found a 3.24-day periodic wobble in the light from Alpha Centauri B, a star just 4.3 light years away. They attributed this to the gravity of a planet with that orbital period pulling on the star.

But now, Vinesh Rajpaul of the University of Oxford and his colleagues have shown that the signal could have been introduced by the way measurements were made (arxiv.org/abs/1510.05598). The fact that the telescope could only look at this star occasionally may have created a rhythm in the signal that had nothing to do with planets.

To check, the team simulated signals that looked close to the originals, but didn't include any planets. They then used the original team's model to analyse the fake data, and were still able to see a spurious 3.24-day signal

"Given what we've shown, it seems very, very implausible that the planet is real," says Rajpaul.

Musicians know how to take it slow

NOT a fan of slow jams? Maybe you haven't had enough training.

When we listen to music or speech, electrical waves in our brains synchronise to the tempo. But some people's brains are better at syncing to the beat.

Keith Doelling at New York University and his team recorded brainwaves of musicians and non-musicians as they listened to music. While both groups could synchronise their brain waves to the rhythms, non-musicians struggled to sync to particularly slow music, with some saying they couldn't keep track of the tempo (*PNAS*, DOI: 10.1073/pnas.1508431112).

Musicians can do this not because of natural talent, Doelling thinks, but because they have been trained to mentally subdivide music into shorter sections. Since a similar process happens for speech, musical training might help people with dyslexia, he says.

Cervix test predicts a baby's birth date

READY for the big event? A simple test could make it easier to predict when a baby is due.

Estimates of when a woman will give birth can be off by weeks. But a test, usually used to monitor women at high risk of giving birth prematurely, seems to also predict whether labour will begin within the next week in women who have reached full term.

The test uses an ultrasound probe to measure the length of the cervix. This is normally between 3 and 5 centimetres, but shortens in the run-up to giving birth. Once it measures 1 centimetre or less, a woman has an 85 per cent chance of delivering within the next seven days (*British Journal of Obstetrics and Gynaecology*, doi.org/8m8).

Saving face for *Sunflowers*

THE brilliant yellows in four of Vincent van Gogh's famous *Sunflowers* paintings are fading fast. Now a map details the parts most at risk, which could help protect them from further damage.

Four of the seven *Sunflowers* paintings were made with a class of pigments called chrome yellows, which are based on chromium and lead. Van Gogh mixed and layered these yellows to produce subtle contrasts and shades. But which of the vibrant hues seen today are the work of a master painter, and which are due to chemical degradation, has been debated for decades, says Letizia Monico of the University of Perugia in Italy.

Her team used high-powered X-rays to analyse microscopic samples from the version at the Van Gogh Museum in Amsterdam, the Netherlands. Some of the lead chromate at the painting's surface had turned into greenish chromium oxide, which combined with the underlying yellow to produce a darker and browner hue than van Gogh may have intended.

The team also produced a "high risk" map showing which regions contained the most light-sensitive pigments (*Angewandte Chemie*, doi.org/f3jpnd). That will come in handy when the painting in Amsterdam is restored, set to happen in the next few years.

VAN GOGH MUSEUM, AMSTERDAM (VINCENT VAN GOGH FOUNDATION)

Stingless Brazilian bees farm fungi to feed their larvae

FLOWERS aren't enough. For the first time, bees have been seen farming fungus to provide food for their larvae.

Though farming is well-known in social insects, such as ants and termites, bees had been thought to depend solely on pollen and nectar for sustenance.

But it seems a Brazilian stingless bee, *Scaptotrigona depilis*, struggles to survive without a crop of the fungus.

Cristiano Menezes of the Brazilian Agricultural Research Corporation and his team found the white *Monascus* fungus growing in all of the 30 bee nests they looked at. The fungus only grew inside the cells that the social bees build to house their growing larvae – and the young larvae devoured it with gusto.

When the team tried to grow the bees in the lab without the fungus, the survival rate of the larvae dropped dramatically – from 72 per cent to just 8 per cent (*Current Biology*, doi.org/8qj).

The fungus also profits from this arrangement, because bees offer it a protected environment and food inside larval cells, and disperse it to new colonies.

This important relationship raises concerns about the use of fungicides. While not directly harmful to bees, they may be affecting them by killing off their symbiotic fungi, the team says.

There may be more farming bees to be found. "Given the substantial diversity of bees, many of which are poorly studied, it is likely that other bees engage in similar associations," says Cameron Currie of the University of Wisconsin.

Death of plankton exaggerated

GOING, going, not gone! The rate at which phytoplankton are disappearing as oceans warm has been vastly overestimated by a glitch in models.

That's good news, given that these tiny ocean plants and microbes support other marine life, remove half the carbon dioxide from the atmosphere each year and produce up to 70 per cent of the oxygen we breathe.

Estimates of the abundance of these photosynthesising cells are calculated by looking at levels of the green pigment chlorophyll in satellite images of the oceans. The images appeared to show that plankton numbers fall as the ocean temperature rises.

But plankton can adjust how much chlorophyll they make depending on light conditions. When Michael Behrenfeld of Oregon State University took that into account, he found it can explain more than 85 per cent of observed changes in chlorophyll levels (*Nature Climate Change*, doi.org/8qh).

Yet he thinks plankton will still suffer under climate change, because warmer surface water does not mix well with colder, nutrient-rich lower layers.

TUI DE ROY/MINDEN

King penguins face longer commute

WHERE did all the fish go? Strong climatic events, such as this year's El Niño, can force king Penguins to travel further in search of fish, threatening their very survival.

For king Penguins on the Crozet Islands in the southern Indian Ocean – home to some 700,000 breeding pairs, nearly half of the wild population – an increase in water temperature of just 1 °C means the difference between life and death.

During the summer months, the penguins swim out from the islands to forage at the Antarctic polar front, a major ocean boundary with an abundance of sea life.

But, during extreme climatic events in the region, the front can shift by 130 kilometres, doubling the penguins' return trip, says Charles-André Bost of the Hubert Curien Multi-disciplinary Institute in Strasbourg, France.

Bost's team studied penguin foraging trips from the islands between 1992 and 2010. In 1997, during the strongest El Niño year on record, the penguin breeding population decreased by 34 per cent (*Nature Communications*, DOI: 10.1038/ncomms9220).

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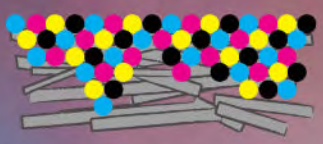

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Does your CV have the right keywords?

The AI headhunters

Computers often have the final say over whether your CV ever makes it into human hands, says **Chris Baraniuk.** Is there a better way?

APPLYING for a job can be a soul-destroying process. First you have to polish your CV and make sure your covering letter matches the job description. Then you send them off into the void, hoping they will catch the eye of a recruiter who will call you in for an interview.

But no human may ever read your résumé. For the past few years, the world's biggest firms have been using AI recruitment software to filter job applications and streamline the process, and smaller businesses are increasingly interested, too.

That should make selection fairer and less open to abuse, in theory. But it can also make it harder to get a foot in the door (see "Found wanting – by a machine", opposite). Now a number of companies want to change the way AI helps find the right person for the job.

Existing applicant tracking systems (ATS) typically scan applications for keywords that the employer has selected. The software might prioritise sections of the CV in which those words appear alongside more recent positions, for example. Any CVs that don't fit the bill are instantly rejected; those that pass are stored and indexed for a human recruiter to look through.

Career coach Pamela Skillings believes applicants should assume that their application will be screened by an algorithm, and quite probably rejected, before a human ever looks at it. But such systems are hardly foolproof. They don't just frustrate people looking for jobs with non-traditional CVs – they are also far from ideal for employers. For example, excessively rigorous screening can mean relevant sections of a CV will be passed over if they contain words and phrases only slightly different from the employer's preselected ones, and the candidate rejected.

"Jobseekers should assume their application will be screened by algorithm and quite probably rejected"

"Sometimes there's a little bit of conflict between HR and the actual managers because they're saying, 'What are these résumés I'm getting?' says Skillings. "Or, 'Someone I know applied and they didn't get through – there's something broken here between what you're screening for and what we actually want.'"

Moves are afoot to make the recruitment algorithms more sophisticated. The biggest name in online recruitment is Silicon Valley giant LinkedIn, and a few weeks ago it unveiled its revamped Recruiter app at a glitzy event in Los Angeles.

On stage, Eduardo Vivas, head of LinkedIn Talent Solutions, showed how typing the names of two software developers he manages into a search box would cause the system to sift millions of LinkedIn users for matching talents. Then it displayed a list of candidates at other companies with like-for-like skills and experience.

"Instantly, I see people on the platform that look just like them," he said. "The ability to take our best people and find people just like them is incredibly powerful." Another of the firm's algorithmic innovations is that employers will be able to narrow down huge lists of existing contacts to find those with the skills appropriate for a recently advertised job.

A button for itchy feet

The app will also indicate how often a prospective candidate has interacted with the company's posts on LinkedIn and show whether he or she is actually looking for a new job right now. This bit of knowledge will be picked up thanks to the "something new" button coming to LinkedIn profiles. By clicking on it, users on the social network can tell employers – except, of course, their own – that they have itchy feet.

Other companies are going even further to cherry-pick the best candidates. Connectifier, founded by ex-Google staff, markets itself as a search engine for recruiters. The firm's algorithms crawl a range of websites and candidates' profiles, as well as CVs, to build up a picture of skills and expertise.

"We can look at things in finer detail – things that a recruiter might have a hard time taking into account. Like, does someone have a lot of friends in a certain location or at a certain company?" says CEO and co-founder John Jersin.

The system can also, for instance, harvest data from a site like GitHub, where programmers share and discuss code.

"If they're posting a significant amount of code online, we know that they know the language they're writing in," says Jersin. "If they're answering a lot of questions about a specific language or technology, we have a lot of information about their knowledge on those skills."

It's not the only such technology out there. Reveal is a small Danish start-up touting "a machine learning engine for your recruitment". The software has been trained on professional vocabulary relating to job descriptions and is able to analyse databases of CVs, looking for candidates who might fit a post.

The firm's algorithm uses statistical models that look at the distribution of words. It understands that "software engineer" or "software developer" are very similar roles, for example.

Six Danish firms have been testing the system on open job positions. "Because we had a lot of résumés in the database we could actually detect patterns," says Jonas Krarup, one of Reveal's founders.

Krarup and his co-founder Joel Raucq say their approach could help companies with large numbers of CVs on file to make the most of that data and identify good candidates as soon as new roles come up. The system can even predict how interested a candidate might be in a job change from their current position. This is done by assessing how many previous jobs candidates have listed on their CV and noting how frequently they have moved from role to role.

"AI selection will only work if recruiters and algorithm designers carefully define what they really want"

Of course, there are those who resist the encroachment of AI on recruitment. Unsurprisingly, headhunter Nick Corcodilos is not a fan.

"The reason companies need technology to sort through so many résumés is because they mindlessly solicit so many," he says. Corcodilos thinks that firms should move away from online recruiting, and he worries that "potentially outstanding" candidates are being unfairly ruled out by some systems.

For Skillings, AI has great potential in recruitment but, she adds, it will work only if recruiters and algorithm designers are willing to take the time to carefully define what they really want in a candidate.

"The end result could be that algorithms could actually identify people who would be great at the job," she says, "but might not have ever been given a second look under the traditional keyword scan." ■

FOUND WANTING – BY A MACHINE

For 10 months, Alyssa Mathews has been looking for her first full-time job. She has sent off well over 100 applications, so far to no avail. It's not that she's underqualified – she has a master's degree in environmental science. Instead, she thinks she is falling foul of CV-screening algorithms.

"I've got rejection upon submission, where I submit my application and it immediately rejects me," she says. "I know that's just a computer, and I failed some sort of algorithm or test." She believes that because her CV is highly interdisciplinary, the computer perceives it as lacking specialisation.

Since discovering more about how the algorithms work, Mathews has changed tactics and begun approaching recruiters at job fairs. She is now getting many more interviews.

Some find the problem insurmountable, though. One 48-year-old graphic designer who wished to remain anonymous says she has sent out several hundred applications in recent years. A large number of rejections, she suspects, are to do with her age and gaps in her CV.

"I've met a lot of people in my exact situation," she says. "Over 40, unemployed for over three years and they know that it's over."

ONE PER CENT

DOUG PENSINGER/GETTY

Drones for ski action

Time to bust some moves. Two major ski resorts in Colorado want to use drones to film their skiers' sickest stunts. Copper Mountain and Winter Park want to create "Drone Zones" where a staff member uses a drone to film skiers or snowboarders in action. People will be charged up to $200 to have their best moves captured from the air and receive an edited highlights reel the next day. The firm providing the drones, Cape Productions, has worked with the US ski team during training.

2 trillion

The number of public posts by people on Facebook that the firm has made accessible to users via the search function on the site.

Self-driving taxi?

Uber is getting into the mapping game. After a photo of one the firm's street-mapping cars was posted to a private Facebook group, Uber admitted that its cars have been on the road for several months, with Microsoft mapping technology strapped to their roofs. Uber could be using them to pave the way for self-driving cars, which need extremely accurate and precise 3D maps of the road to function.

Robots of the Caribbean

Land ho! Fleets of cheap bots could map the seas for us, finds **Anna Nowogrodzki**

HYDROSWARM

Is it a ball? Is it a brain? No it's a robot

THE planet's surface is more than 70 per cent water. Yet we know more about the moon than we do about what's going on in the deep oceans. A Massachusetts start-up has a ball-sized robot it wants to fix that.

Meet EVE – the Ellipsoidal Vehicle for Exploration – a sensor-studded yellow robot the shape of a rugby ball. EVE's creator Sampriti Bhattacharyya, a mechanical engineer at the Massachusetts Institute of Technology, has a grand mission in mind for a swarm of EVEs: she wants to build Google Maps for the ocean.

"We do not yet have a very cheap, scalable, easily deployable method of scanning large areas of the ocean," says Bhattacharyya, who founded her company Hydroswarm to commercialise EVE and do exactly that. The start-up is one of 26 finalists for the MassChallenge Awards, which will select winners at the end of the month to receive a share of $1.5 million in grants. These awards are designed to help fledgling start-ups get off the ground.

Existing ocean-going robots are remotely operated, but EVE is autonomous, making it cheaper and more feasible to use swarms of them to search large areas. "With a swarm you can get faster coverage of a big area," says Yogesh Girdhar of the Woods Hole Oceanographic Institution in Massachusetts.

Such a network of autonomous drones could be used for disaster response, coral reef monitoring, surveillance for port security and finding places to drill for oil and gas. Bhattacharyya says EVE would have been useful for monitoring pollution from the BP oil spill. Its elliptical frame can be fitted with the right sensors for its mission, such as environmental sensors to monitor pH changes. A swarm of them could be used to look for missing aircraft by fitting the robots with acoustic sensors to listen for pings from a downed jet's black box.

"It can be operated as a single drone or as a kind of sensor network," Bhattacharyya says.

Mapping the ocean is difficult. "Underwater, if two robots are talking to each other, they pollute the entire sound channel," says Girdhar. "That means everybody else on the network has to stay quiet." And he says EVE is probably too small for some sensors, such as those that measure ocean current. It's also tricky to do real-time video processing underwater. "These are all challenges, but they're all solvable theoretically," Girdhar says.

> **"Autonomous robots are most needed underwater. The future is small robots, and a lot of them"**

Another challenge is battery life: one charge currently lasts EVE only two and a half hours, so the length of its expeditions is limited.

Bhattacharyya says the robots will be in operation very soon.

"I think autonomous robots right now are most needed underwater", rather than in aerial or land environments, says Girdhar. "Hopefully these kinds of start-ups will bridge that gap. I think the future is small robots, and a lot of them." ■

Stress tests for medics keep tabs on their health

HOW stressed is your doctor? A large-scale test of wearable stress monitors, announced this week, is set to provide some answers.

Boston start-up Neumitra will test its wearable devices with 1000 or more doctors and nurses in January next year. It will measure stress levels at two of Boston's biggest hospitals – Massachusetts General Hospital and Beth Israel Deaconess.

"Stress can impact on the common cold all the way up to a heart attack," says Aditi Nerurkar, a stress management clinician at Beth Israel Deaconess. Although we know stress affects the health of patients, medical professionals themselves have a culture of stoicism about their health, she says.

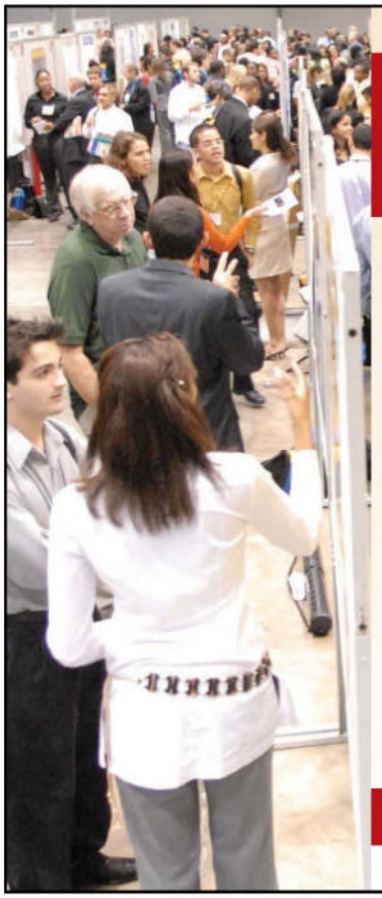
Neumitra's devices look like smart watches. They take physiological measurements – of heart rate, temperature, motion and skin conductance – and use an algorithm to convert the data and display it as a number from 1 to 10, with 10 being the highest stress level. They can also use colour coding: blue for low stress, red for high. The devices vibrate when your stress level increases.

The stress monitors can sync with a smartphone calendar, colour-coding times that were particularly stressful, or mapping apps, highlighting areas in the city where you feel most stressed.

Neumitra is hoping its system will become a standard for stress measurement. It is working with companies that make smart watches and Fitbit-style fitness trackers to have them include its "Bio+" stress-measuring technology. The first such devices will be available in early 2016, says Neumitra founder Robert Goldberg.

Nerurkar hopes that tracking stress will remind medical professionals to take care of themselves, as well as their patients. "It's time for us as doctors to recognise that we're human first, and doctors second," she says.

Anna Nowogrodzki ■



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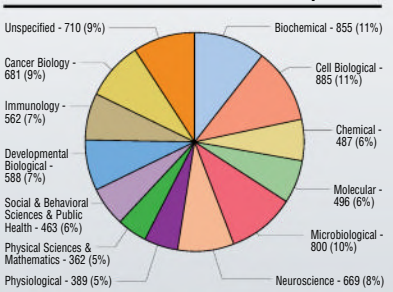
"Attending and winning in my category was one of the best experiences in my scientific life. Coming from my background, I doubted myself in the past. I now feel confident because when I presented my poster I left like I belonged. This conference really made me believe that I can pursue a career in science." STUDENT

2014 Distribution of Scientific Disciplines



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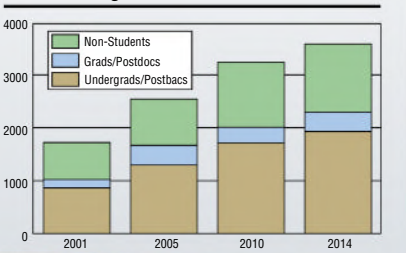

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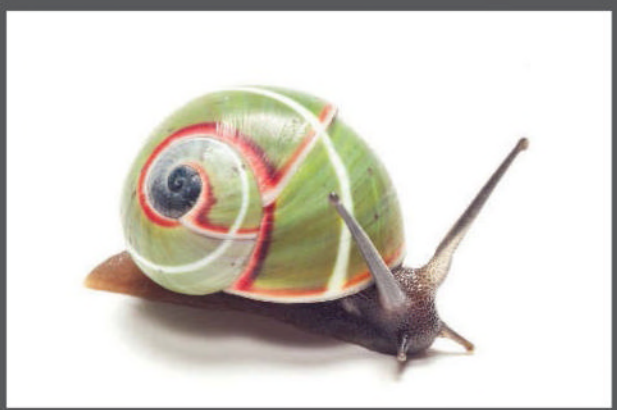
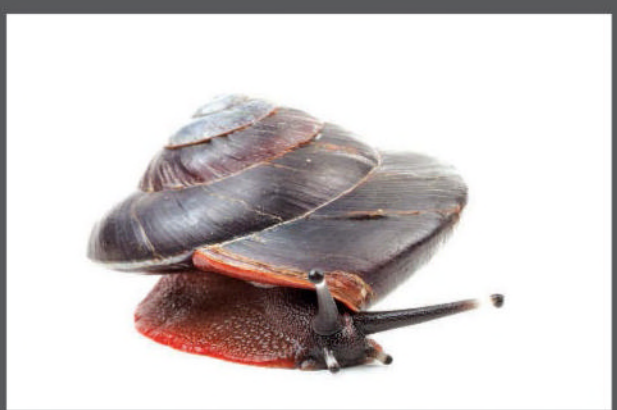




Here's lookin' at you

NO, THAT'S not a minor character from the latest *Star Wars* movie. This exotic-looking creature with its anteater-like snout is *Tropidophora cuvieriana*, an example of the incredible diversity and, yes, strange beauty of land snails.

"Most people think land snails are just ugly and slimy, and some are," says photographer Ingo Arndt. "But many species are also very beautiful and show interesting behaviour."

He decided to photograph the land snails' beauty and coloration as he travelled around the world. He saw a wide variety of shell colours and patterns, for example the tree snail of the genus *Amphidromus* (right, top) and the Cuban land snails *Polymita venusta* (right, second from top) and *Polymita picta iolimbata* (right, bottom). *Caracolus excellens* (right, second bottom) has a distinctive flat, black shell. "I think these animals deserve it that we show their beautiful side," he says.

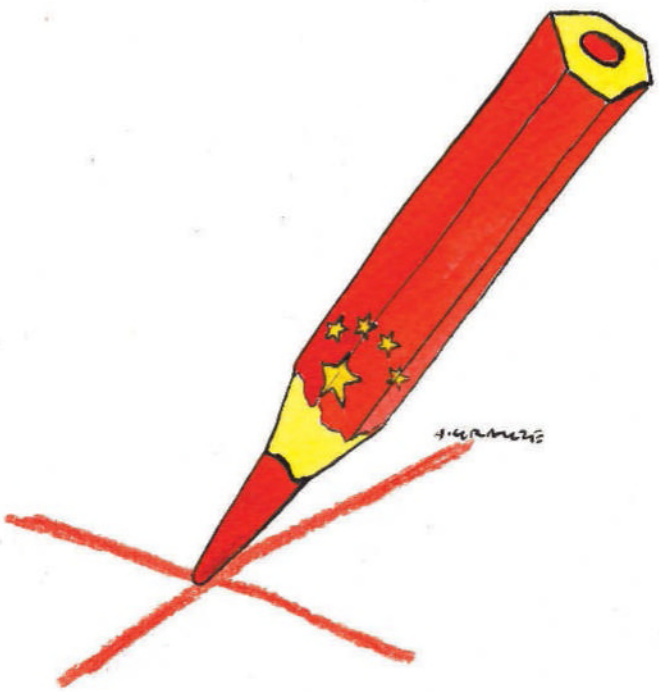
But Arndt also wanted to bring the snails' plight to the public's attention. Like other animals, habitat destruction and pollution mean that thousands of snail species are endangered. Around a tenth of the 200 known species have probably disappeared.

These beauties also face another threat: shell collectors. With the Cuban snails in particular, Arndt notes that many are smuggled out of the country to fill collections across the globe. "Some important areas are already empty [due to collectors]," he says. Rachel David

Photographer
Ingo Arndt
ingoarndt.com

End the censorship

China must stop the suppression of data and debate on its deadly air-pollution problem, says **Rachael Jolley**



THERE was plenty of pomp and ceremony, political protest and business dealing during Chinese president Xi Jinping's state visit to the UK last week. Less was said about the pressing issue of dirty air and the censorship around it in his country.

The visit was an ideal chance to urge for research on pollution levels and environmental issues to be released to the Chinese people, so they can be fully informed about risks to their health and, where possible, take precautions. The Chinese government often seeks to restrict the latest data on pollution and its impact.

Globally, about 7 million people died in 2012 because of bad air quality, according to estimates from last year by the World Health Organization. The information it used was mapped by Yale University's Center for Environmental Law and Policy, and showed that China is among the worst for exposure to fine particulate matter, a pollutant that can harm health. A recent US study put the toll in China at 4000 lives a day.

But when a documentary called *Under the Dome*, which tackled the issue of air pollution in China, was shown there earlier this year, it was soon removed from view.

The film discussed microscopic airborne soot clearly and accessibly. The presenter, Chinese environmental activist Chai Jing, spoke about its impact on her life and that of her 6-year-old daughter. The film is now being compared to Rachel Carson's book *Silent Spring*, which highlighted the damage caused by pesticides in the US.

After its release, *Under the Dome* went viral across the world, with reports about its censorship

Unhealthy stealth

Trust in new medical tech depends on openness over results, says **John Ioannidis**

THE age of "stealth research" is upon us – in case you hadn't noticed. Work that could transform healthcare is under way, yet the results don't appear in peer-reviewed journals.

This issue has been brought to the fore by the case of Silicon Valley biotech firm Theranos. Its consumer blood test, combined with innovative lab technology, promise fast, accurate results relevant to dozens of illnesses, using pinprick samples, and at low cost.

Not so long ago, I warmly applauded Theranos for seeking clearance from the US Food and Drug Administration for its proprietary diagnostic tests, but cautioned that FDA clearance alone is not enough to protect consumers. Fast-forward to mid-October, when the *Wall Street Journal* ran an investigation with multiple anecdotal examples of potential issues with the company's technology. Theranos has rebutted these, via its lawyers and in statements to the media.

But what about the science? I have long advocated that all medical research be transparent. If tests rely on a new technology, we need to know it works. That's why I have favoured large-scale randomised trials for health-related interventions, testing by publicly funded stakeholders with no vested interests, improved peer review, thorough publication of findings, and the sharing of protocols and data sets.

"Strong evidence supports disruptive technologies and makes a better case than any advert could"

Such measures will ultimately benefit innovators: strong evidence buttresses disruptive technologies, and makes a better case than any advert could.

Given that health-related technology is ultimately about life-and-death situations, drugs have to prove their worth in randomised trials. For other

drawing global attention.

Now it seems this was not the only way the Chinese government chose to restrict information to the public, according to research published in the current issue of the magazine *Index on Censorship*. Matthew Auer of Bates College, Maine, and King-wa Fu of the University of Hong Kong studied how Weibo, China's answer to Twitter, had also been censored, with hundreds of posts related to the film being removed. These covered subjects such as demonstrations and accusations that the government was not taking responsibility for dirty air.

President Xi has stated that he is committed to cleaning up pollution, and has appealed to the public to participate in this. But people need open information to do so.

Air pollution is not just the problem of one nation: air doesn't respect borders, so there are implications for other countries.

Surely Xi's responsibility is not to stifle debate, but to share scientific research and data with his own people and other governments, so that the best way to tackle this ever-increasing problem can be found. ■

Rachael Jolley is editor of quarterly global magazine *Index on Censorship*

aspects of healthcare, including lab testing, standards of evidence are lower. Laboratories can get accreditation, but for new technologies this is not enough.

Scientists need to know how a technology works and why it has advantages or disadvantages over existing ones. They need to see all the evidence. I trust in innovation, and perhaps Theranos will change the medical world. But first of all it needs to show us the data. ■

John Ioannidis is professor of medicine, health research and policy, and statistics at Stanford University. He is also co-director of its Meta-Research Innovation Center

ONE MINUTE INTERVIEW

The brain collector

Dissecting the brains of people who took part in an IQ study 70 years ago could help us all in old age, says **Chris Henstridge**

PROFILE

Chris Henstridge at the University of Edinburgh, UK, analyses the brains of people from the Lothian Birth Cohort study of childhood intelligence

How do you persuade people to agree to donate their brain after death?

People can understandably be a bit squeamish about the idea of handing over their brain. But these are people we've been working with face-to-face, doing cognitive testing, for over a decade so we know them fairly well. We send them a letter so they have the opportunity to think about it with their family without any pressure.

There are several other brain banks, why is yours different?

It is the only one where the people had their intelligence tested 70 years ago. It started with the discovery of a box of old IQ test scores in a basement of the University of Edinburgh. At that time, the UK government believed the population was becoming less clever because better-off couples were having fewer children than the "lower classes" – just crazy! They tested the IQ of 11-year-olds in 1932 and 1947 to see how intelligence shifted. A comparison of the results – published in *The Annals of Eugenics* – showed that intelligence was in fact slightly increasing, so the project was shelved.

Why did your team resurrect this research?

Retesting those people first tested in 1947 now they are approaching their 80s is an incredible resource for learning how we can stay mentally sharp into old age. Many things have been claimed to help, like drinking red wine or learning new languages. But the picture might be getting muddied because those things also correlate with baseline intelligence in childhood: it's not that drinking red wine keeps you sharp, it's that if you are clever to start with you are more likely to be middle class and therefore drink red wine. But if you know childhood IQ, you can take this into account. We have shown that some of these popular myths are actually rubbish.

What is gained by dissecting brains as well?

It may shed light on the idea of cognitive reserve. This suggests that if you spend your life reading books, being socially active and healthy, it helps your brain to form more connections, or synapses. When you get older and start to lose some synapses, these extra ones can retain your cognitive performance into old age.

Are you able to count synapses in brain samples?

Yes. We are using a technique that cuts pieces of brain tissue into 70-nanometre-thin slices that we look at using fluorescent microscopy. Then our computer reconstructs the sections into 3D shapes, so we can count the synapses. We will look at 38 different areas of the brain.

How far along is the project?

So far 173 people have agreed to donate their brains and the first two brains have just come in. Obviously it is too soon to draw conclusions, but as the study progresses we are going to gather valuable information. We are also about to start sequencing the genomes of participants and take blood samples so we can create personalised stem cells for each one and grow them into neurons, for testing in the lab. It's a very exciting time.

Interview by Clare Wilson

Photographed for *New Scientist* by Ken Richardson

Looking out from behind someone else's face

There's a part of you that has nothing to do with what you see in the mirror, discovered **Carmen Blandin Tarleton** following a horrific attack that left her with 80 per cent burns

What was it like to see your changed appearance after you were attacked in 2007?
Doctors put me in a coma to operate on me after the attack. When I woke up, I was completely blind for the first two years, so I didn't really know what I looked like. It wasn't until October 2008, the beginning of the court case, that I realised I looked significantly bad: the TV news coverage came with a graphic content warning. For a year and a half I didn't feel good about the way I looked – I made little kids cry. Eventually I had to accept it. But when I did regain enough eyesight to see myself in the mirror, it was difficult. I couldn't see who I was before. Even my eye colour had changed. I couldn't see me in there. It was disturbing.

How did you feel when your doctor, Bohdan Pomahač at the Brigham and Women's Hospital in Boston, suggested a face transplant?
I was surprised. I didn't know he was doing them. After he first suggested it, I looked online at the pictures of people he had already performed face transplants on. I was shocked – it was just such a transformation. I wanted that transformation for myself. It seemed a little sci-fi, but he told me it would also be a real opportunity to regain some function in my face. That was what I was most concerned with. For example, I have synthetic corneas in my eyes that were bearing the brunt of not having eyelids, which meant I couldn't blink.

Did you have to wait long for a suitable donor?
Yes. Because I'd had so much surgery and blood from other people during the many procedures, it was difficult to find a tissue match. By the time I was on the list for a face transplant, I had already had 58 surgeries. They couldn't find me a donor until 14 months later, and even then we were not a complete match. As a result, I take high doses of immunosuppressive medications that stop my body from rejecting the face.

How did you prepare for the face transplant?
When you agree to the transplant, psychologists and psychiatrists evaluate you, but they don't really tell you anything. A social worker was always on hand to answer any questions I had. I was a registered nurse for 20 years, and I took care of kidney and liver transplant recipients, so I was well versed in the medications.

How did you feel just before the surgery?
That was one of the most surreal moments of my life. It was emotional, but at the same time it wasn't. It was glorious because I knew things were going to change for the better, but it was also heartbreaking that someone had died. It was as if time had stopped while this big event was happening.

What happened during the surgery itself?
I don't know much about it. The doctors took pictures and scans beforehand to find out what wasn't working and what I was missing from my scarred face. The left side of my face didn't work well. I could barely move it. I didn't have eyelids, so I couldn't blink. I couldn't breathe out of my nose. I didn't have lips. They made a map of everything I would need from a donor. It was a huge undertaking. The surgery lasted about 17 hours.

What was it like to wake up with a new face?
I couldn't see my face at first because it was swollen, and I couldn't see out of my eye. It was probably a good 10 days before I looked in the mirror. During that time, I wasn't afraid or worried, given how disfigured I had been before. It was a big relief to look in the mirror that first time. I looked good.

How has your recovery been?
My recovery was quite long. But by the end of the first year, I could see improvements. I could start to close my mouth and smile a bit. I could open my left eye just enough, and blink it a little bit, which was all I really needed. I can eat without drooling and now I have lips. I can breathe out of my nose for the first time since I was injured. Those kinds of things mean a lot. When I woke up after the transplant I couldn't feel my face at all. Now I've gained about 65 per cent sensitivity in my face. A lot has changed in the two years since I had my surgery.

Your appearance has changed dramatically. Do you still feel like you?
I now have a whole different face that doesn't look anywhere near the way I used to look. I now see a pleasing image in the mirror – I'm not all scarred, and I appreciate that – but I still don't see me. After seeing my old reflection for 40 years it is going to take a while to look in the mirror and not think, "Hey, this doesn't really look like me". I've sort of gotten used to it. It's not stressful – being disfigured was a lot more stressful. ›

PROFILE
Carmen Blandin Tarleton, a nurse from Vermont, was left with 80 per cent burns after she was attacked and doused with industrial-strength alkali by her estranged husband. Two years ago, she became one of the first people in the world to receive a full face transplant

What are your treatments like now?
There is always surgery for me because my body is 80 per cent burned. Even if I'm not going to have surgery on my face for a while, I always need scar releases. I have huge scars, and they are so tight that they keep my arms and legs from moving. I need surgery to cut them from time to time, and cover them with skin grafts. Those kinds of surgeries are much more painful than the face transplant. I also have biopsies taken from my face every six months. Doctors look at the tissue and can tell whether or not the face is being rejected.

Have there been any signs of rejection?
All face transplants have shown signs of rejection at one time or another. I've had three episodes. They usually happen in the winter months. Sometimes I put a steroid cream on my face, and sometimes my medication is increased. It usually takes about six weeks for the biopsies to return to normal. It's nothing to get upset about.

A different tune: Carmen Blandin Tarleston has learned to play the banjo since her horrific attack

Will your ability to feel and use your face continue to improve with time?
Yes. I've recently had a little setback – a nerve or muscle is not working correctly on the left side of my mouth, which has started to droop. It happened after I gave a talk to teenagers, and then posed for about 300 photos, so I might have overused it. Things like that set me back, but I think it's looking better as time goes on.

When you have setbacks like this, should you rest your face, or perhaps exercise it?
My doctors aren't really sure because this is all so new. There are no guidelines to follow, so we play it by ear. In this case, my speech therapist is going to give me a call. I'll do the exercises she tells me to do to see if I can recover from this setback, which I think I can.

Three months after you received your face transplant, you met Marinda Righter, the face donor's daughter. What was that like?
It was great. It was her decision to meet me. We've had a really good relationship since. She was the person that gave permission for her mother's face to be donated. Her mother was a registered organ donor, but given the newness of the procedure the doctors asked for special permission to take her face, and Marinda agreed to that. The faces of most people who have face transplants change significantly over the years. I don't know why, but my face hasn't changed much, so Marinda still sees her mother in me.

Do you think the experience has changed you in other ways?
It has. I wasn't happy being disfigured, but I also knew that I didn't have to let it stand in my way. I felt like I needed to shine my light within so brightly that my looks on the outside wouldn't be so bothersome. I give a lot of talks. My partner has taught me to play the banjo, so we play banjo together at the end of my talks. I have a great life.

Most people will struggle to imagine coming to terms with such a dramatic change in their appearance.
The only thing I can say is that it really makes you realise that there's a part of you that has nothing to do with what you look like. That part of you has nothing to do with the person you see in the mirror. ■

Interview by Jessica Hamzelou

FACE TRANSPLANTS BACKGROUNDER

Face transplants involve removing significant amounts of damaged facial tissue and replacing it with healthy tissue from a donor. The exact number is unknown, but between 30 and 35 face transplants are thought to have been performed around the world, since Isabelle Dinoire received the world's first partial face transplant in France in 2005.

Different surgical teams use different procedures, but Bohdan Pomahač, who performed Carmen Blandin Tarleton's transplant at the Brigham and Women's Hospital in Boston, uses a conservative technique that minimises the amount of tissue to be grafted. He tries to avoid making a complete swap.

Pomahač's team first examines the patient's face, before removing only those parts that are damaged beyond repair. They then cover the removed areas with fat, muscle and skin from a carefully selected donor. Nerves and blood vessels are painstakingly reconnected under a microscope.

Once the surgery is complete, face-transplant recipients have a lifetime of follow-up treatments. There is always a chance that a person's immune system will attack the foreign tissue, called rejection. A fully rejected face might "just slough off and die in pieces", says Pomahač, or it could scar over and stop working.

LONG-TERM PROSPECTS

Pomahač hasn't yet seen any complete rejections, but recipients tend to have small episodes about once a year, which can be controlled with immunosuppressant drugs.

He hopes all the face transplants will last for life, but he can't be sure. People who receive liver and kidney transplants can sometimes develop chronic rejection against these organs over the years, he says. "Only half of transplanted kidneys are still functioning 10 years later, which is a sobering thought."

All seven of Pomahač's face-transplant recipients are doing well, and their ability to feel their new faces seems to be improving with time. Their ability to control facial muscles has also got better with time and use, although these improvements seem to plateau about three years after the operation.

Pomahač says he is looking to perform the procedure for more people, but any candidates will have to pass a screening process before they can be considered. His team will only perform the surgery for people whose disfigurement can't be addressed with established, less-invasive surgery. They have also turned down people who are not medically well enough to undergo the procedure, and those that are unable to fully understand the risks involved.

HARRY GRUYAERT/MAGNUM PHOTOS

Quiet revolutions

The first people to till the earth weren't ploughing such a lonely furrow, finds **Bob Holmes**

IN FEBRUARY 1910, British botanist Lilian Gibbs walked across North Borneo and climbed Mount Kinabalu, a lone white woman among 400 locals. She later wrote: "The 'untrodden jungle' of fiction seems to be non-existent in this country. Everywhere the forest is well worked and has been so for generations."

What Gibbs saw was a seemingly curated tropical forest, regularly set alight by local tribes and with space carefully cleared around selected wild fruit trees, to give them room to flourish. The forest appeared to be partitioned and managed to get the most rattan canes, fibre for basketry, medicinal plants and other products. Generation after generation of people had cared for the trees, gradually shaping the forest they lived in. This wasn't agriculture in the way we know it today but a more ancient form of cultivation, stretching back more than 10,000 years. Half a world away from the Fertile Crescent, Gibbs was witnessing a living relic of the earliest days of human farming.

In recent years, archaeologists have found signs of this "proto-farming" on nearly every continent, transforming our picture of the dawn of agriculture. Gone is the simple story of a sudden revolution in what is now the Middle East with benefits so great that it rapidly spread around the world. It turns out farming was invented many times, in many places and was rarely an instant success. In short, there was no agricultural revolution. "We're going to have to start thinking about things in a different way," says Tim Denham, an ›

archaeologist at the Australian National University in Canberra.

Farming is seen as a pivotal invention in the history of humanity. Before, our ancestors roamed the landscape gathering edible fruits, seeds and plants and hunting whatever game they could find. They lived in small mobile groups that usually set up temporary homes according to the movement of the prey they hunted. Then one fine day in the Fertile Crescent, around 8000 to 10,000 years ago – or so the story goes – someone noticed sprouts growing out of seeds they had accidentally left on the ground. Over time, people learned how to grow and care for plants in order to get the most out of them. Doing this for generations gradually transformed the wild plants into rich domestic varieties, most of which we still eat today.

This accidental revolution is credited with irreversibly shaping the course of humanity. As fields began to appear on the landscape, more people could be fed. Human populations – already on the rise and stretching the resources available to hunter-gatherers – exploded. At the same time, our ancestors traded their migratory habits for sedentary settlements: these were the first villages, with adjoining fields and pastures. A steadier food supply freed up time for new tasks. Craftspeople were born: the first specialised toolmakers, farmers, carers. Complex societies began to develop, as did trade networks between villages. The rest, as they say, is history.

RED-FACED FACTOID: TOMATOES WERE FIRST FARMED IN PERU OR MEXICO – BUT WE STILL HAVE NO IDEA WHEN

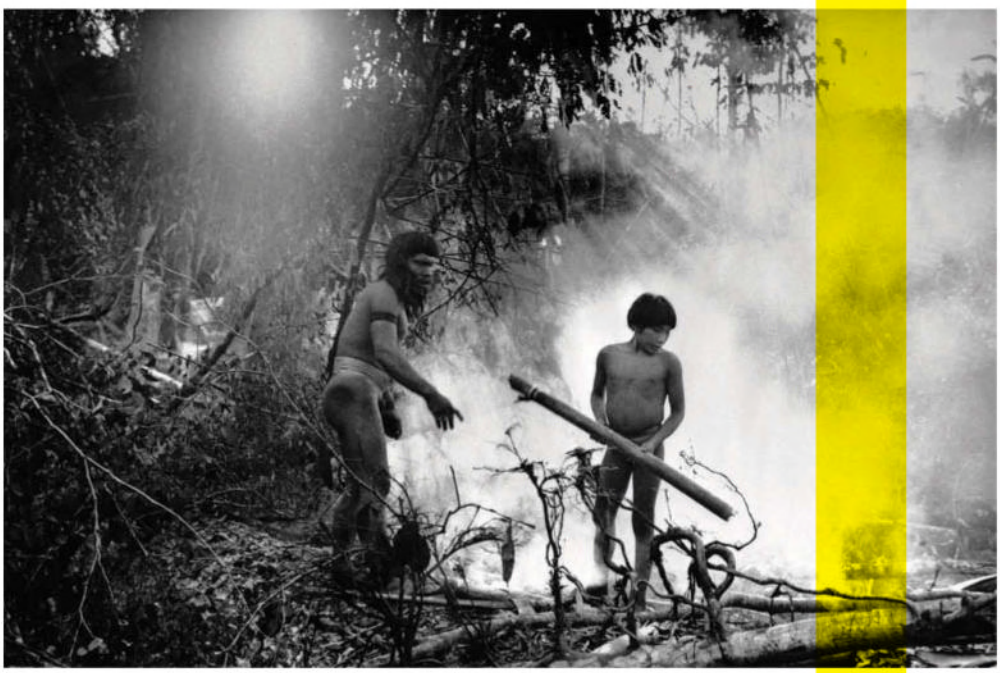
The enormous impact of farming is widely accepted, but in recent decades the story of how it all began has been completely turned on its head. For starters, while the inhabitants of the Fertile Crescent were undoubtedly some of the earliest farmers, they weren't the only ones. Archaeologists now agree farming was independently "invented" in at least 11 regions, from Central America all the way to China (see map, page 33). Decades of digging have kicked up numerous instances of ancient proto-farming, similar to what Gibbs saw in Borneo.

Another point archaeologists are rethinking is the notion that our ancestors were forced into farming when their populations outgrew what the land could provide naturally. If humans had turned to crops out of hunger and desperation, you would expect their efforts to have intensified when the climate took a turn for the worse. In fact, archaeological sites in Asia and the Americas show that most early cultivation happened during periods of relatively stable, warm climates when wild foods would have been plentiful, says Dorian Fuller of University College London.

Nor is there much evidence that early farming coincided with overpopulation. When crops first appeared in eastern North America, for example, people were living in small, scattered settlements. "The sites are less than 10 houses and they're not very numerous," says Bruce Smith, an archaeologist at the Smithsonian Institution in Washington DC. "There's no real evidence that population increase was the prime mover causing them to shift over to domesticated crops." The earliest South American farmers also lived in the very best habitats, where resource shortages would have been least likely. Similarly, in China and the Middle East, domesticated crops appear well before dense human populations would have made foraging impractical.

Instead, Smith suggests, the first farmers appear to have been pulled into experimenting with cultivation, presumably out of curiosity rather than necessity. "These are additional food supply sources, but otherwise the subsistence system based on wild species pretty much remains unchanged," he says. That lack of pressure would explain why so many societies kept crops as a low-intensity sideline – a hobby, almost – for so many generations. Only much later in the process would densely populated settlements have forced people to abandon wild foods in favour of near-exclusive reliance on farming.

Those first experiments most likely happened when bands of hunter-gatherers started tweaking the landscape to encourage the most productive habitats. On the islands of South-East Asia, people were burning patches of tropical forest way back ›

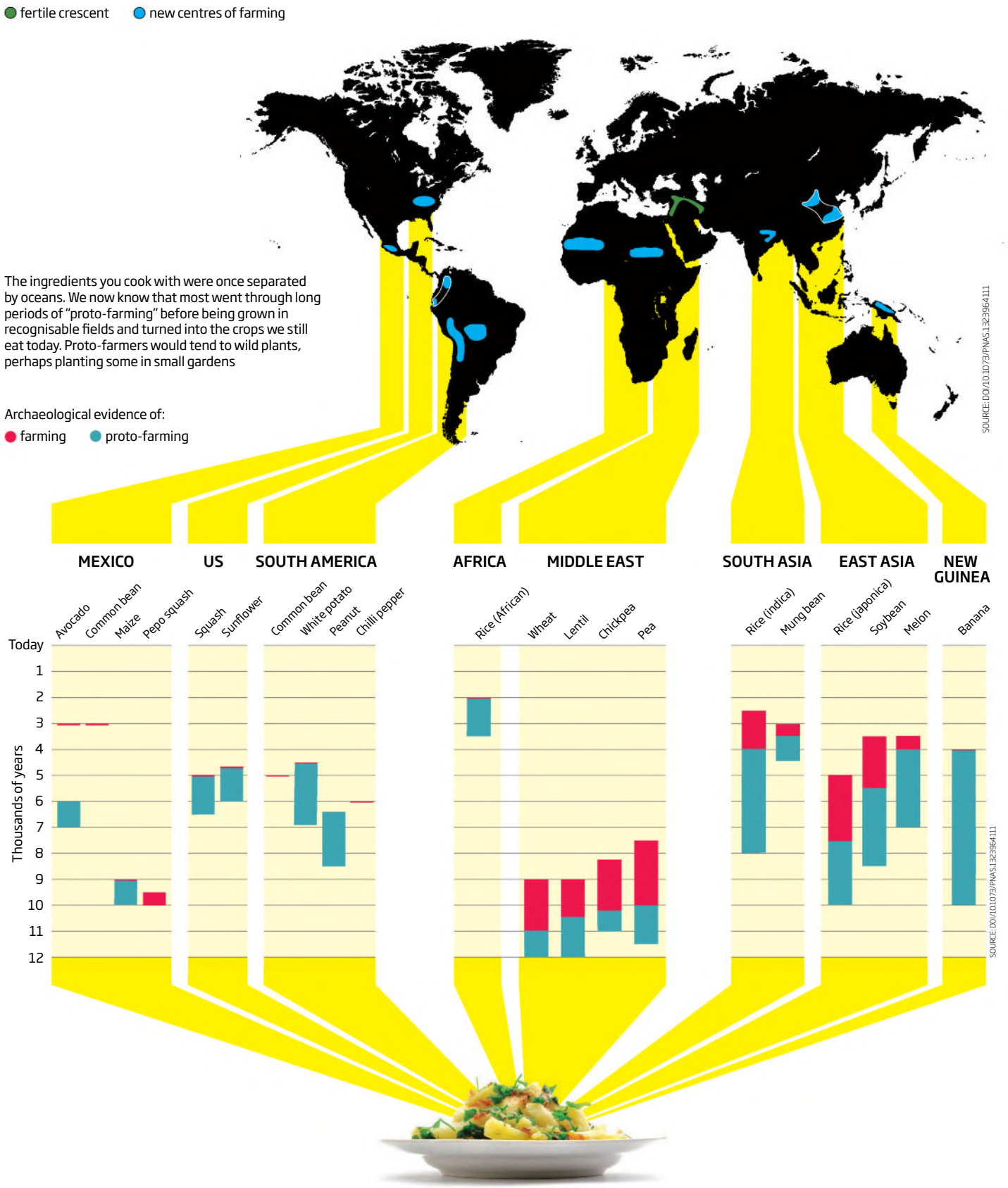


Setting forests alight is now- as it was then - a clever way of shaping forests to produce food

CORNELL CAPA © INTERNATIONAL CENTER OF PHOTOGRAPHY/MAGNUM PHOTOS

Where did all the potatoes come from?

Our picture of the dawn of farming is being redrawn. Gone is the simple story of a sudden agricultural revolution in the Fertile Crescent at the end of the last ice age that spread around the world. Archaeologists now agree that farming was "invented" at least 11 times in 11 different places



CUSCUS TO SLAUGHTER

Domestic food animals, traditionally viewed as a later add-on in the development of agriculture, may have been part of the picture from the very beginning. In fact, the roots of animal husbandry probably stretch back into the last ice age.

There is some evidence that the common cuscus, a small marsupial native to New Guinea, appeared on remote islands such as New Ireland 20,000 and 10,000 years ago, at the same time as the first humans arrived. The cuscus is a favoured prey for modern hunter-gatherers, so the suspicious timing may mean early Pacific islanders brought the animals with them to seed their new home with prey.

In the Fertile Crescent of south-west Asia, skeletal remains of sheep and goats suggest that by 10,500 years ago, humans living in what is now Turkey were preferentially killing young male animals, says Melinda Zeder, an archaeologist at the Smithsonian Institution. This implies that they were not just hunting the animals, but deliberately managing herds to maintain fertile females. She is now looking at 11,700-year-old sites for evidence that the practice began even earlier. If she is successful, it would imply people began domesticating animals in the region at the same time as they began domesticating crops like wheat and barley.

So why have historians assumed that animal domestication came second? Further south in the Levant, the most common prey animal back then was a species of gazelle whose behaviour made it unsuitable for domestication.

Since most archaeologists working in the region have tended to study the Levant, which is more accessible, this may have led them to the erroneous conclusion that animal domestication lagged behind that of plants, says Zeder.

Pity the common cuscus: cute but tasty

ROBIN MOORE/NATIONAL GEOGRAPHIC CREATIVE

during the last ice age. This created clearings where plants with edible tubers could flourish. In Borneo, evidence of this stretches back 53,000 years; in New Guinea, 20,000 years. We know the burns were deliberate because the charcoal they left behind peaks during wet periods, when natural fires would be less common and people would be fighting forest encroachment, says Christopher Hunt of Liverpool John Moores University, UK, who has worked in Borneo for many years.

Burnt riches

Burning forest would have paid off for hunters too, as game is easier to spot at forest edges. At Niah Cave on the northern coast of Borneo, Hunt's colleagues have found hundreds of orang-utan bones among the remains of early hunters, suggesting forest regrowth after a burn brought the apes low enough to catch, even before the invention of blowpipes. Burning probably intensified as the last ice age gave way to the warmer, wetter Holocene beginning about 13,000 years ago. Rainfall in Borneo doubled, producing a denser forest that would have been much harder to forage without fire.

This wasn't only happening in South-East Asia. Changing climates also pushed hunter-gatherers into landscape management in Central and South America. At the end of the last ice age, the perfect open hunting grounds of the savannahs began to give way to closed forest. By 13,000 years ago, people were burning forests during the dry season when fires would carry, says Dolores Piperno, also at the Smithsonian Institution. Researchers are now turning up evidence of similar management activities in Africa, Brazil and North America.

From burning, it is just a short step to actively nurturing favoured wild species, something that also happened soon after the end of the ice age in some places. Weeds that thrive in cultivated fields appear in the Fertile Crescent at least 13,000 years ago, for example, and New Guinea highlanders were building mounds on swampy ground to grow bananas, yams and taro about 7000 years ago. In parts of South America, traces of cultivated crops such as gourds, squash, arrowroot and avocado appear as early as 11,000 years ago, says Piperno.

Evidence suggests that these people lived in small groups, often sheltering under rock overhangs or in shallow caves, and they tended small plots along the banks of seasonal streams in addition to foraging for wild plants.

Their early efforts wouldn't have looked much like farming is today. "It's better to see it as small gardens," says Fuller. "Small, intensively managed plots on riverbanks and alluvial fans – possibly not all that important in terms of the overall calories." Instead, Fuller thinks these gardens may have provided high-value foods, such as rice, for special occasions. "It's like growing something for Christmas dinner instead of year-round meals," he says.

As Gibbs discovered in Borneo, and others have seen elsewhere since, this kind of proto-farming is still practised by some hunter-gatherer tribes today. They often move every few years as local game populations are depleted, leaving behind fruit trees that their descendants may return to decades later. Hunt recalls meeting a man gathering fruit in the forest near Niah who told him he was harvesting the trees "that my grandfather planted for me". (Sadly, as younger people abandon their traditional lifestyles, this multi-

"THEY LIVED IN SMALL GROUPS IN SHALLOW CAVES, AND TENDED SMALL PLOTS ALONG THE BANKS OF SEASONAL STREAMS"

MATTHIEU PALEY/NATIONAL GEOGRAPHIC CREATIVE

Cream of the crop: maize has changed through the ages

generational knowledge is rapidly being lost, says Hunt.)

Archaeologists have long assumed that this proto-farming was a short-lived predecessor to fully domesticated crops. They believed that the first farmers quickly transformed the plants' genetic make-up by selecting traits like larger seeds and easier harvesting to produce modern domestic varieties. After all, similar selection has produced great changes in dogs within just the past few hundred years.

We'll farm... maybe

But new archaeological sites and better techniques for recognising ancient plant remains have made it clear that crop domestication was often very slow. Through much of the Middle East, Asia and New Guinea, at least a thousand – and often several thousand – years of proto-farming preceded the first genetic hints of domestication.

In China, for example, people began cultivating wild forms of rice on a small scale about 10,000 years ago. But physical traits associated with domesticated rice, such as larger grains that stay in the seed head instead of falling off to seed the next generation, didn't appear until about two-and-a-half millennia later. Fully domesticated rice didn't appear until 6000 years ago, says Fuller.

Even after crops were domesticated, there was often a lag, sometimes of thousands of years, before people began to rely on them for most of their calories. During this prolonged transition period, people often act as though they haven't made up their mind how much to trust the newfangled agricultural technology.

The inhabitants of China's Yangtze delta about 6900 years ago, for example, lived primarily on wild foods like acorns and water chestnuts. They also grew a small amount of partially domesticated rice, often in small depressions just a metre or two across. But Fuller has found that rice makes up only 8 per cent of plant remains in archaeological sites in the region. Three hundred years later, the use of rice had tripled, and yet wild foods still made up the bulk of the diet. "They're keeping their options open," says Fuller.

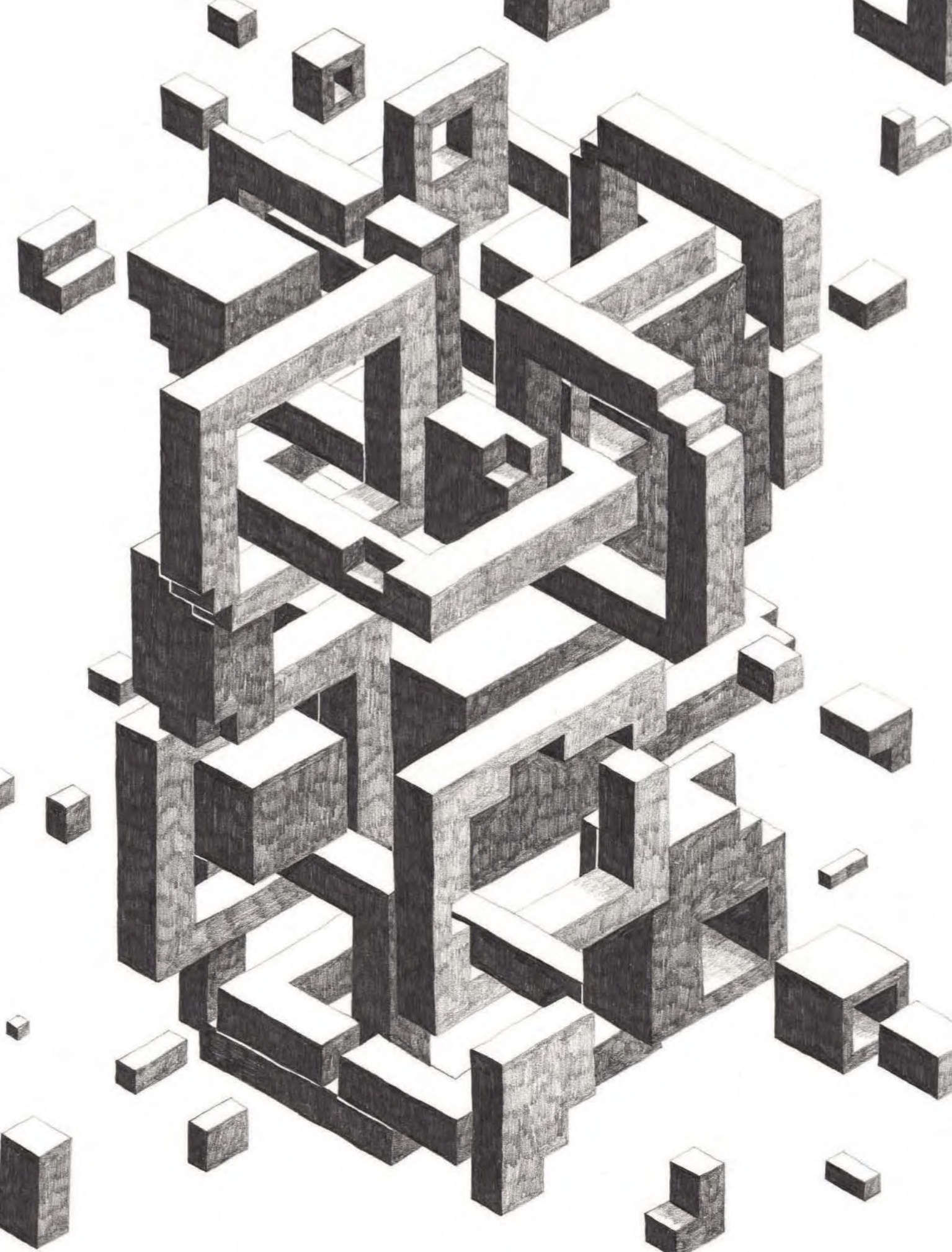
The record also shows a long period of overlap in other regions, with cultures using both wild foods and domesticated crops. We know from the type of starch grains found on their teeth that people living in southern Mexico 8700 years ago were eating domesticated maize, yet large-scale slash-and-burn agriculture did not begin until nearly a millennium later. In several cases – Scandinavia, for example – societies began to rely on domesticated crops, then switched back to wild foods when they couldn't make a go of farming. And in eastern North America, Native Americans had domesticated squash, sunflowers and several other plants by about 3800 years ago, but only truly committed to agriculture about AD 900, says Smith.

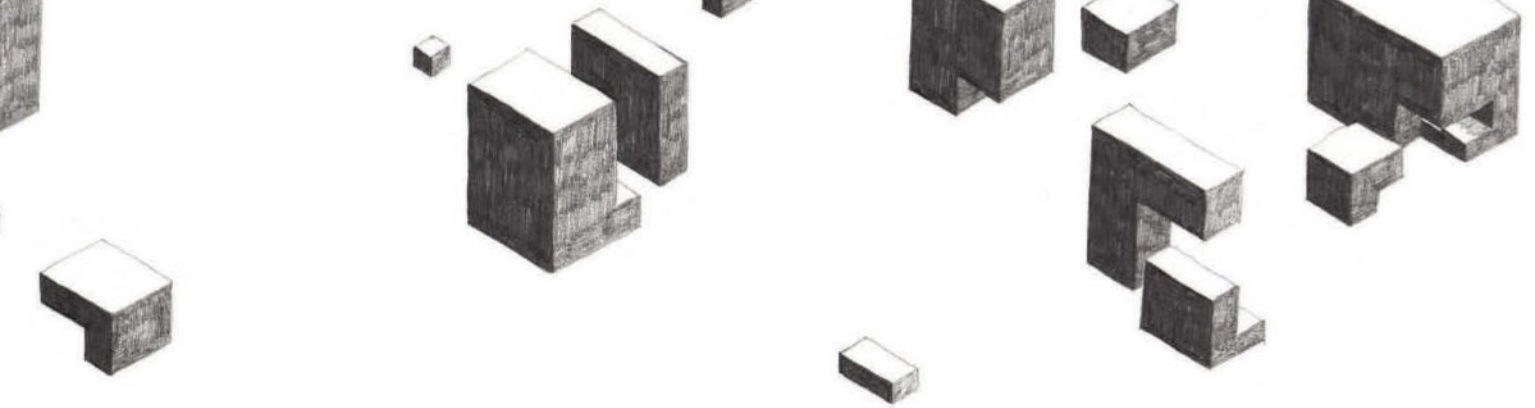
Indeed, some cultures didn't commit to domesticated crops until modern times. The highlanders of Borneo, for example, only began growing domestic rice after the second world war. Many of the indigenous crops grown by traditional New Guineans, like sago palm and some tubers, are even now only semi-domesticated at best, says Denham. One reason may be that traditional gardening hunter-gatherers use so many plants – often a different mix for each month of the year – that their crops experience very little evolutionary pressure toward domestication.

The story of agriculture, in short, is not the sudden agricultural revolution of textbooks, but rather an agricultural evolution. "The evidence is showing a much more patchwork-quilt mosaic, with different sorts of practices and different plants being used in different ways," says Denham. "In those conditions, when agriculture emerges over time, it's a long, drawn-out process. It's a much more diffuse event, both in time and in space."

That means people's motivations for making the switch were equally complex, as crops become gradually more dominant in their lives. "If people are cultivating plots, their life is going to be oriented to those areas," says Denham. "That would require a shift in their way of engaging with the landscape, and with each other as well. That's really why we're interested in it – because it's a story about us." ■

Bob Holmes is a consultant for *New Scientist* based in Edmonton, Canada





TRUST NO ONE

Need to share a secret? You'll want a cipher that's as strong as the laws of physics, says Michael Brooks

THE Romans had a saying in praise of a reliable man: "You can trust him in the dark." But as Julius Caesar realised when several members of his inner circle stabbed him to death, sometimes the best course of action is to trust no one.

Throughout history, people have been burned by misplaced trust. Users of the extramarital affairs website Ashley Madison, whose details were leaked in August, are a good example. Their spouses are another. But as far as cybersecurity is concerned, we are finally poised to create a world in which trust is optional. The development taking us there is called device-independent quantum cryptography. Once it is perfected, you will be able to buy a secure device from your worst enemy and still be certain that no one is spying on the messages you send using it. "You don't have to trust anyone," says Artur Ekert, the University of Oxford physicist whose innovations in cryptography led to the idea.

This perfectly secure future can't arrive quickly enough, as present-day cryptographic systems are in a precarious state. The security of all of our online purchases, bank transactions and personas rely on a single shaky assumption: that certain mathematical operations are hard to do. The best known of our modern encryption systems is called RSA. To encode data, it builds a key from two very large prime numbers. These are kept secret, but their product – a number thousands of binary digits long – is public knowledge. Data can be encoded using this public key, but only those with knowledge of the original numbers can decrypt it. RSA's security relies on the fact that there is no known shortcut to find the two starting numbers. The only ways to do it are almost interminable processes, such as trying all the possibilities one by one.

Or so we hope. "We cannot prove that these problems are inherently difficult," Ekert says. It's not impossible that someone will discover a procedure allowing a conventional computer to quickly factorise the product of two huge primes. Maybe they already have and they're cleverly keeping it secret. If such an algorithm ever came to light, internet transactions would collapse, and financial deals and top secret government communications would be exposed. "It would truly be a catastrophe," says Michele Mosca of the Institute for Quantum Computing in Waterloo, Canada. "It's like a Y2K problem, except we don't know precisely when it might happen."

Even if we could prove that the factorisation problem is beyond the abilities of traditional computers, there are still quantum computers to consider. Because they compute using quantum phenomena they could consider all the possible primes at once. In 1994 mathematician Peter Shor, now at the Massachusetts Institute of Technology, showed this would be a speedy process. Simple quantum computers already exist and advanced machines able to realise Shor's idea can't be far off.

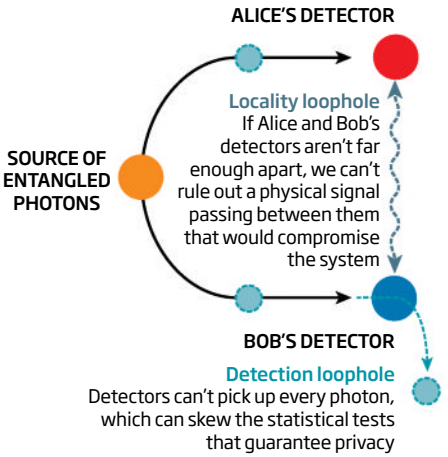
One way to reinvigorate our privacy is to fight fire with fire and employ quantum cryptography. This promises the ability to create keys that are entirely random, entirely unpredictable and totally inaccessible to spies.

Quantum cryptography hinges on the rules that govern particles like photons or electrons. Their properties, including polarisation for instance, take multiple values at once, only snapping into sharp definition when measured. Use these properties as a basis for encryption and you preclude any attempt to peek at your key: that would change the result of the measurement, in effect destroying the key's tamper-proof seal. The technique has already been used to protect hospital data, ›

JAMIE MILLS

Talking in secret?

Alice and Bob like to encrypt messages using entangled photons, but two loopholes can compromise privacy



financial transactions and voting in the Swiss general elections.

Current systems use a protocol where the person transmitting the key, usually referred to as Alice, releases a polarised photon and makes a measurement on it before sending it. Her listening partner, usually referred to as Bob, chooses a particular way to make a measurement of that polarisation, and then he and Alice use an unencrypted channel to compare the sort of measurements they did. This allows them to create one digit of a private key for use in encrypting messages. To build the entire key, Alice and Bob simply repeat the process.

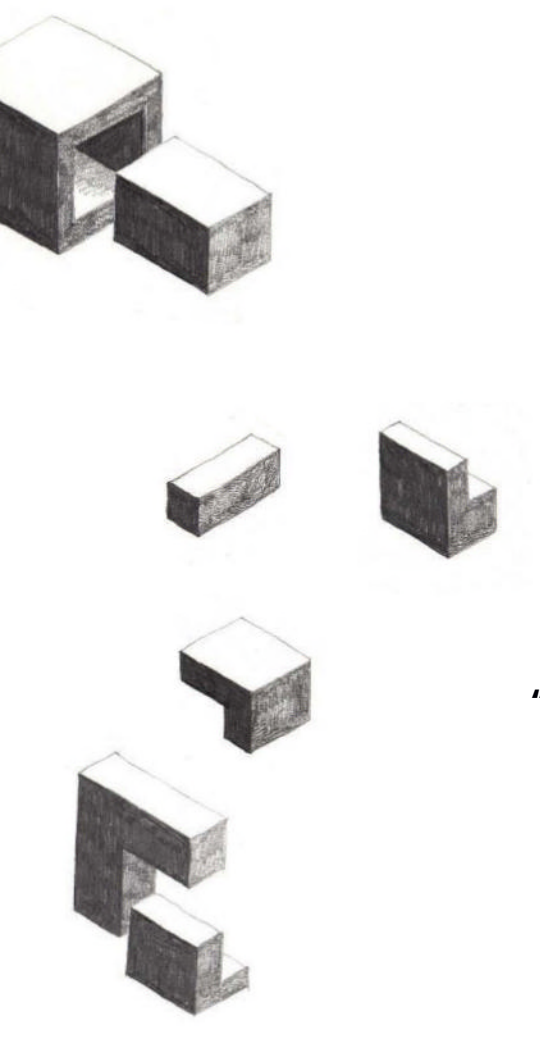
You might think that's good enough, yet this type of quantum cryptography has weaknesses. "You always have to make some assumptions about certain pieces of equipment," says Vadim Makarov, one of Mosca's colleagues in Waterloo. Makarov is an expert at showing that those assumptions matter, having broken into many "secure" systems around the world. He is the first to admit that you have to go to fantastic lengths to exploit these weaknesses, but when it comes to state secrets, say, or large bank transactions, who's to say nobody would?

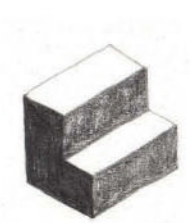
One example of such a vulnerability is known as the detection loophole. It arises because the efficiency of photon detectors is never perfect, making practical quantum cryptography a bit like sending multiple copies of your key via an army of couriers to an office that occasionally shuts for lunch. Alice has to send far more photons than would otherwise be necessary, because Bob can't detect them all. This intermittent detection means Alice and Bob can't be certain that their apparatus is working securely.

It's not impossible to dream up ways of solving these technical hitches, but there's another more subtle problem that comes as an unavoidable side dish and which takes us to the heart of the problem with trust.

Imagine you have bought a state-of-the-art quantum cryptography system. It might well come complete with a shiny certificate guaranteeing its security, but how do you know the manufacturer hasn't built in a covert back door that allows them to read and sell your secrets?

"How do you know the device hasn't got a back door that will leak your secrets?"





It's hardly unthinkable. As soon as a new encryption technology becomes available, governments, corporations and intelligence agencies look for – and may even demand – a hidden flaw that they can exploit. Maybe your machine is programmed to spit out a key matching what someone somewhere has on file. Or perhaps there is a side-channel that logs a copy of any key you generate.

Here's where device-independent cryptography comes in. It started when Ekert came up with a smart new form of quantum cryptography in 1991 (*Physical Review Letters*, vol 67, p 661).

This protocol also uses a stream of photons and, just as before, Alice creates a string of random numbers by measuring a property of each. The twist is that this time Bob has a separate stream of photons from the same source, and his photons are "entangled" with Alice's. Entangled photons are generated in pairs, and their properties are subtly connected. If Alice has one of a pair, and Bob has the other, they can perform measurements on their respective photons that will help them create each digit of a shared key.

So random

Until 2004, Ekert's idea was just another way of doing quantum cryptography, subject to the same old loopholes (see "Talking in secret?", left). But that changed when Antonio Acín of the Institute of Photonic Sciences in Barcelona, Spain, and colleagues realised that this version of cryptography contained a way to check the trustworthiness of the manufacturer. The implications are profound: with this protocol, you could buy the machine from your worst enemy and still be certain that it couldn't leak your secrets. "It came as a surprise to me," Ekert says. "Sometimes your inventions can be cleverer than you are."

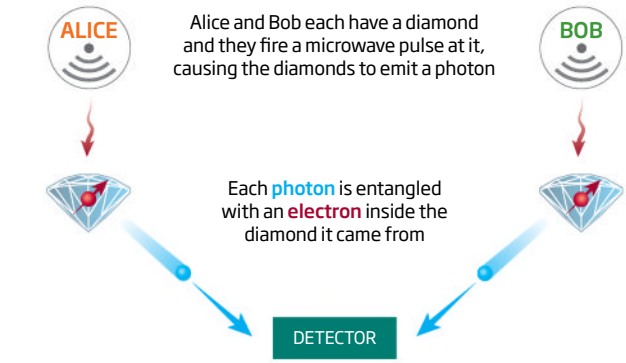
The rules of quantum theory say that the link between two entangled particles is "monogamous": there is no correlation with anything else and so no information can escape to an eavesdropper. Acín's neat insight was that you can prove whether this is the case using something known as a Bell test.

First set out by physicist John Bell in 1964, the test aims to determine whether two sets of numbers are more highly correlated than can be achieved by chance. "The more they are correlated together, the less they can be correlated with anything outside," Ekert says.

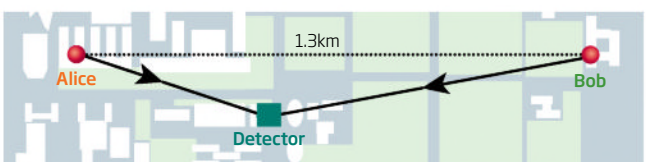
If your system passes the Bell test, you have a cast-iron guarantee of three things. First, that your key is generated on the fly and thus not predictable. Second, that its digits have an inherent randomness, and thus can't be guessed. Third, and perhaps most

Privacy guaranteed

Earlier this year an experiment beat the loopholes that compromise the security of existing quantum cryptography



If the two photons arrive at the detector simultaneously, the entanglement gets transferred: now the electron in Alice's diamond is entangled with the electron inside Bob's diamond. This allows Alice and Bob to have entangled particles without needing to exchange them – and that closes the loopholes



Aerial view of experiment at Delft University, the Netherlands

importantly, that no one is tapping into your key transmission using a back door. If they were, the correlations would be tainted.

There was just one problem with the scheme: no one had built a fully watertight experimental set up to conduct the Bell test. It comes down to the same problems that plague today's versions of quantum cryptography, plus one more that comes into play now we're dealing with entanglement.

This final problem is called the locality loophole. The worry is that there might be some as yet undiscovered signal relaying information between the entangled particles. If there were, that would invalidate our assumptions about randomness and open up the possibility of some genius adversary tapping the signal.

It might seem like madness to be concerned about all this, but there are two good reasons to push ahead. For one thing, get this right and we would have totally eliminated the need for trust. And for another, this is where the story of quantum cryptography intersects with physicists' quest to prove quantum theory is a full and accurate description of reality. Here is an opportunity to slay the lingering doubt about whether there is something beneath the spooky links between entangled particles.

Proving that there isn't would involve a Bell test where the locality and the detection loopholes are simultaneously closed. In the 51 years since Bell published his test researchers did one or the other, but no one had done both at the same time. It's surprisingly hard to do, according to Stephanie Wehner of Delft University of Technology in the Netherlands. "It's like saying I can ride a bike and I can juggle, so I must be able to juggle while riding a bike," she says. "It's not as easy as you might think."

But Wehner and her colleagues finally performed a loophole-free Bell test earlier this year (*Nature*, doi.org/8km). The crucial idea they harnessed in their experiment is called entanglement swapping. The Delft team set up two diamonds, 1.3 kilometres apart on their campus. Imagine our hypothetical Alice being stationed at one, Bob at the other. Each diamond contained a defect known as a nitrogen vacancy centre. Hitting an electron located there with a microwave pulse produces a photon that is entangled with the electron. The team arranged things so that pulses hit both diamonds at roughly the same time and their respective photons shot off to a detector in the middle. Here's the smart bit: if the photons arrived at that central detector exactly in sync, the entanglement would swap from being between each person's electron-photon pair to being shared between the electrons. Now Alice and Bob have a pair of entangled electrons that haven't travelled anywhere (see "Privacy guaranteed", left).

"It's like a Y2K problem except we don't know when it will happen"

Because electrons are much easier to detect than photons, the experiment easily closed the detection loophole. And because the electrons were so far apart, the researchers had a 4-microsecond window in which to measure their correlations – plenty of time in 21st-century physics – and prove that any physical signal that could have created them would have needed to travel faster than light. Since this is forbidden by the laws of general relativity, of course, that took care of the locality loophole.

Under wraps

Thanks to this ingenuity, the correlations passed the Bell test, and we know that they are not due to detector errors, nor to a communication that has a hackable physical mechanism. "That feels good," says Wehner's college Bas Henson who led the project. Finally, we have closed the loopholes; quantum theory has passed the test and we know it can be used to create a certifiably safe cryptographic system.

There are still a few wrinkles. Familiar ones that have always hindered cryptographers. An enemy might break into your office and steal your key, for instance. "Physical security is always an issue," Mosca says. "If I can look into your lab and see the plain text, then I don't need to break your cipher." Makarov points to another caveat: the key distribution might be device-independent, but other parts of the system could be compromised. "You have to trust that no ingredient at the end stations contains some malicious piece," he says.

Those eternal issues aside, though, we have finally reached the end of the road for perfecting security. It will take time to move from proof of principle to application: implementing the protocol is still hard work for now. The Delft team achieved 245 entanglement events in 9 days – not exactly a useful rate for generating a cryptographic key, which might need to be thousands of digits long. But things are improving. "We expect to be able to make entanglement 100,000 times faster in the near future," says Henson.

Device independent quantum cryptography, the last word in secret messaging, does now appear to be within our grasp. The quantum part provides an unbreakable protocol; the device-independence takes the reliability of the supplier out of the equation. "In terms of being able to verify physical security, it's the best," says Mosca. Ekert agrees: the Bell test routine is so simple anyone can use it. "You don't even have to understand physics." ■

Michael Brooks is a consultant for New Scientist

Live and learn

Apps promise to help adults learn languages in their spare time, but can you really become bilingual as you commute to work, asks **Hannah Joshua**

IT WAS time to say tawa pona, or farewell in a language most of us had never heard of 48 hours before. I had joined a group of 17 language enthusiasts who signed up to learn a new way of communicating in just two days. It seemed a lofty goal, but by the end of the experience, we were all reasonably fluent.

As someone who flunked French and German in my teens, the idea that I could pick up a new language so quickly was a revelation. I had labelled myself a lifelong monoglot, and, like many others who never took to languages at school, was discouraged by the idea that once the precious easy-learning window of childhood has passed, the task of mastering a new language becomes an uphill struggle.

Research has now dispelled that notion. The brain does get rewired as you age, and kids do grow up surrounded for much of the day by the language they want to acquire, but being an adult does have advantages when it comes to learning. One of them is probably in your pocket right now.

"Technology is really the way that learning is going," says Rosalind Potts, who studies memory and learning at University College London. Gone are the days of parroting stock phrases from a chalkboard. Mobile devices and the internet are offering us adaptive, personalised ways to absorb more information and make the most of every spare second. "Learning is coming out of the classroom and into the big wide world where people are much more in control," says Potts.

The idea that technology can fast-track us to fluency during stolen moments in our busy lives is an attractive one. My two-day boot camp to learn an artificial language called Toki Pona made use of an app called Memrise – a kind of intelligent flash-card deck that taps into the latest findings in cognitive science to make learning vocabulary easier. It bills itself as "the ultimate memorisation tool for language", and has 5 million users. Another language app, Duolingo, one of the most popular, has accrued 105 million registered users since it launched in 2011, and there are many other similar tools out there (see "Teacher in your pocket", page 42). Such is their popularity that several of the companies behind the apps are now hoping to get their tests approved as recognised language certificates. But does the technology work, and can people really multitask their way to being multilingual?

It's no secret that children tend to find it easier than adults to pick up language skills. Part of that is because children's brains are tuned to discern the sounds of any language, allowing them to develop the right accent. But that ability doesn't last forever, and later in life clumsy accents are hard to shake.

That doesn't mean we should lose heart. There are other reasons why children are quick on the uptake, and insights into the way adults think and learn can help technology recreate the benefits. For a start, kids have adults correcting them whenever they err. Adults are more likely to learn new words through study, and tend to rely on self-testing instead.

This is one area where technology can step in. Testing not only helps us find out what we don't know, but is itself a good way to make words stick. Without a top-up, the strength of memories can halve within a day or two of learning something. After this we continue to forget at a less dramatic rate for some time.

But when is best to test yourself? Test too soon and the benefit might be wasted; too late and you'll have to do some relearning. In 2008, psychologists at Carnegie Mellon University in Pittsburgh, Pennsylvania, put testing to the test. They found that each exam gives your memory a little boost that weakens over time. For optimal learning, you need to be tested soon after first studying, and then at ›

GONCALO VIANA

"There's no harm in making errors – in fact it's probably better for memory"

TEACHER IN YOUR POCKET

There's no shortage of apps to help you learn a language:

CNA SPEAKING EXCHANGE connects English learners with elderly speakers seeking social interaction

FLEEX puts subtitles on videos, gradually adjusting the mix from your native to your target language

LANG-8 lets you blog in a foreign language, while native speakers correct your mistakes

WAITCHATTER tests your vocabulary while you wait for friends to reply using instant messenging

BUSUU is a social media site for language learners around the world

HINATIVE allows you to put language questions – such as the meaning of idioms – to those who know

DUOLINGO treats learning like a game, with points and extra lives to keep you motivated

MEMRISE quizzes you on foreign vocabulary just before you forget

VOXY displays foreign media articles relevant to your interests and at exactly the right level of difficulty

IAIN MASTERTON/INCAMERASTOCK/CORBIS

Je m'APPelle: your tablet won't judge you when you mess up

carefully timed and ever expanding intervals (see graph, opposite). Using this knowledge, the team developed algorithms for optimal test scheduling.

Several companies are trying to capitalise on this idea. Memrise, for instance, shows you a word, then immediately tests you on it. The app also sends notifications to tell you when to practise to boost your decaying memories.

This kind of regular testing was a key part of our first morning learning Toki Pona. But while such drilling certainly gets some words stuck in your head, we still spent much of that time getting things wrong. Toki Pona only has 120 words – creator Sonja Lang designed it to simplify her thoughts – but getting to grips with even a simple language is a tall order before lunch.

Memorable mistakes

Unknown to us, making mistakes so soon might have been useful. The accepted wisdom suggests that getting things wrong hinders learning. "Wrong answers can be quite deleterious for memory because you run the danger of storing them," says Ed Cooke, co-founder of Memrise.

But it's time to rethink this idea, says Potts, whose latest research implies that we'd do well to err more often. Her team asked people to guess the meanings of Basque words. None of the participants knew the language, so their guesses tended to be wildly wrong. However, this group had better recall in a subsequent test than a group who just read translations of each word.

"As long as you get feedback then there doesn't seem to be any harm in making errors, and in fact it's probably better for memory," Potts says. She reasons that a desire to know the right answer after making a wrong guess means people pay more attention to the feedback, which creates stronger memories.

The potential embarrassment of messing up renders many adults mute when abroad. But testing yourself with an app, chatting to strangers over social media or using a foreign language blogging platform like Lang-8 – where native speakers correct your errors – all provide a non-judgemental environment for making mistakes.

Our Toki Pona learning marathon rivalled another advantage that children ostensibly have over adults. Kids spend lots of time immersed in a new language. The turning point for us came on the second morning, when we banned English. There was awkward silence at first, but we soon began to venture

School is an immersive language-learning environment

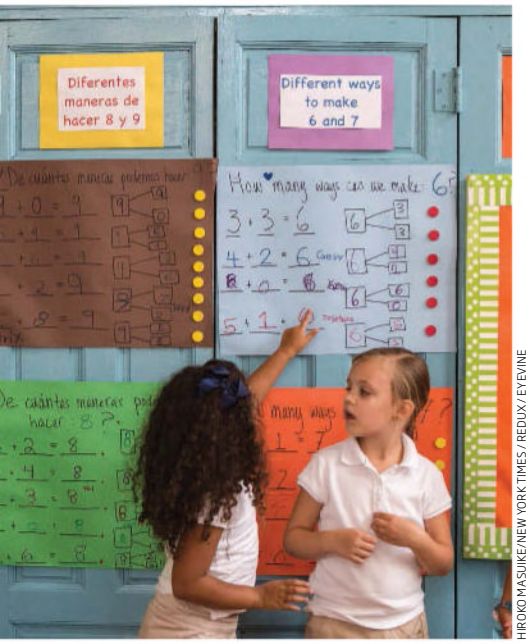
phrases and were forced to get creative. Coffee was "telo pimaje wawa", which means powerful dark liquid.

But according to Katie Nielson, chief education officer of Voxy, which has a digital tool for English learners, immersion might not be ideal for adults. "It's impossible to learn a second language the way you learn a first language because your brain is structured differently," she says. "If you take adults who don't know anything and you put them into an environment where everyone is speaking this new language, they're not going to learn it. They need to have it offered to them at a level that they can understand."

Part of the reason might be because adults can think about their use of language in a way that children can't. This helps with learning vocabulary. Children are learning new concepts at the same time as they're learning how to express them. For adults, when it comes to learning the word for love, say, in another language, there's no need to build the concept of love from scratch; you just attach a new label to your existing association. Love is still love in Sweden even if it is called *kärlek*.

But too much thinking about language can make learning a new grammar tougher. In one recent study, researchers asked two groups of people to listen to an artificial language. One group was told to pay attention to the words. The other was given tasks like colouring as a distraction. Although both groups picked up the rules governing word order, those who had concentrated had a harder time working out which out of three categories a novel word would belong to.

All this hints that the best approach might be a combination of techniques. If there are some aspects that we pick up more easily without overthinking them, apps that allow



HIROKO MASUIKE/NEW YORK TIMES / REDUX / EYEVINE

you to learn passively – for instance by watching a foreign film – could be just the ticket. When it comes to grammar, some digital tools can make learning more implicit.

Estonian physicist Mait Müntel was working at CERN near Geneva, Switzerland, when he realised he wasn't interacting with his French colleagues. But learning French was a daunting prospect. To make the task more manageable, he wrote algorithms that would adapt to his strengths and weaknesses as he learned. The system starts off with simple sentences, getting you to fill in easy nouns or basic present-tense verbs, but gets more challenging as you improve, adjusting the example sentences to make you practise the things you're worst at more frequently. "It constantly calculates in real time what you should do to be most efficient," says Müntel.

The method worked for him. "I learned for a couple of months, then passed the national examination of French that usually people take after learning for 10 years in school," he says. Müntel is now one of a team developing the program, called Lingvist, promising to get people speaking French in 200 hours or less.

So, app-based learning can be effective, and what's more, it's enjoyable. Our Toki Pona marathon proved the power of games in language learning. How do you describe a spider in a language that only has 120 words? We played Pictionary, hangman, charades – anything we could think of that might help. That interaction and competition was a boon, so it comes as no surprise that many apps use levels and badges to keep learners keen.

Research suggests that games can lower language learning anxiety, but with games specifically designed to teach language, the bells and whistles can be distracting. In one study, people who watched an interactive language game being played could recall more vocabulary than those who actually played it. The cognitive burden of playing and learning was too great.

But what of other games? Dionne Palmer of the University of California, Davis, looked at whether it would be possible to use the online multiplayer game *World Of Warcraft* to learn Spanish, just by changing the location settings. After 370 hours of playing over eight months, she improved her Spanish literacy skills to an extent equivalent to two academic terms of classroom instruction, or roughly 200 hours. It's a major time commitment, but if you are playing anyway, just switch your settings and learn.

Enjoyment can also come from tapping into the endless online content aiming to give learners a choice of relevant material. Nielson says this maintains motivation because the learned skills seem relevant, and providing people with material tailored to their interests can also help them decipher unfamiliar words.

With so many factors influencing how we learn, it's not easy to identify the best mix of tools to suit a learner's needs. "We tend to study techniques in isolation and we don't know the effect of combining them," says Potts. But with millions of users, apps provide a mine of information about what works.

Memrise recently launched a competition to figure out the most effective way to use a single hour of study time. And Voxy has begun a partnership with the University of Maryland, using tests to measure learners' working memory and preferred learning styles in order to better personalise instruction.

The big question is whether the skills gleaned from digital tools translate to the real world, or whether people's language scores improve simply because they get better at using the technology itself. That's hard to test, and so far relatively little research has been done. One way is to pit the technology against traditional standards. Last year, Roumen Vesselinov of the City University of New York and his colleagues showed that, on average, Duolingo users took 34 hours to cover the material needed to pass one semester of a language test commonly used for university placements. "What seems to matter most is not how much you do, but how regularly," he says. The team is now conducting studies on other apps.

"What seems to matter most is not how much practice you do, but how regularly"

This kind of independent evaluation is important not just for casual learners, but also because the technology is catching the eye of formal educators. "I am constantly getting questions from school district representatives looking to buy language apps," says Vesselinov. "All of them want efficacy measures for the most popular apps."

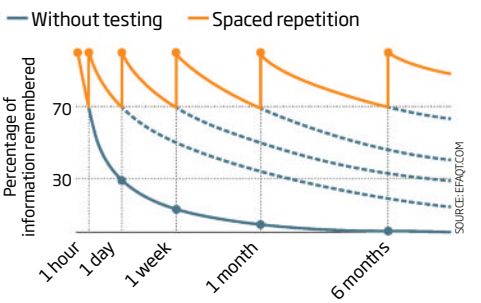
Companies behind the technologies also want to establish their credentials by having users gain recognised language qualifications. Duolingo, for example, has set up a paid-for testing service, and Voxy and another popular platform called Busuu have deals with Pearson, a company that sets one test for English as a foreign language, accepted by governments and universities.

From personal experience, I can say that digital tools are making language learning fun and engaging, and that they can give you the confidence to at least give it a try. I gave up learning Toki Pona (along with my fears about remaining a monoglot), and applied the same tools and techniques to Swedish.

By swatting up on vocabulary on my commute, watching subtitled Scandinavian dramas in the evening, and writing on my Lang-8 blog, I managed to surprise my Swedish-speaking partner by holding court on Valentine's Day, just three months later. There's no better way of showing your *kärlek* than that. ■

Timetabled testing

Scheduling tests at just the right time can stop you gradually forgetting what you have learned. The longer since you first encountered the information, the less often you need to practise



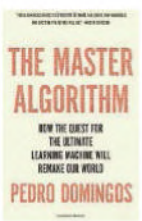
Hannah Joshua is a subeditor at *New Scientist*

To hear Hannah speak Toki Pona, visit bit.ly/NSLanguage

A world remade

Are we sleepwalking towards a strange new society, asks **Anil Ananthaswamy**

The Master Algorithm: How the quest for the ultimate learning machine will remake our world by Pedro Domingos, Basic Books/Penguin, $29.99/£20



WHEN machine learning algorithms that replace newspaper reporters became fodder for a recent episode of Comedy Central's *The Daily Show*, it was clear that the technology had gone mainstream.

But as Pedro Domingos points out in *The Master Algorithm*, machines that learn have been deeply involved with our lives for a while. If you use Google, Netflix, Amazon, Pandora, Yelp, Xbox or just about any online dating service, your life is being run by algorithms that are learning more and more about you by chomping on the data you, sometimes unwittingly, provide.

"Society is changing, one learning algorithm at a time. Machine learning is remaking science, technology, business, politics and war," writes Domingos, a computer scientist at the University of Washington, Seattle.

For people in his field, the problem is that there are myriad such algorithms, each trying to discern patterns in the masses of data we produce. "Machine learning is about prediction," he writes, "predicting what we want, the results of our actions, how to achieve our goals, how the world will change."

The book is about the quest for that one master algorithm which would change machine learning, and hence our lives, irrevocably. If it exists, says Domingos, the master algorithm can derive all knowledge in the world "past, present, and future – from data". In theory, such an algorithm could derive Newton's laws from the astronomical observations of Tycho Brahe, with no a priori knowledge of such laws.

But why should such an algorithm even exist? Domingos provides compelling arguments from neuroscience, evolution, physics, statistics and computer science. For instance, the cerebral cortex might be an instance of such an algorithm: some neuroscientists think that it implements the same algorithm all over, just tweaked to learn to see or hear, or to make sense of touch.

Depending on your world view, the development of a master algorithm is either really thrilling or downright scary. It's not surprising that Domingos, an expert in machine learning, has a very optimistic view. He clearly sees the master algorithm as

MARTIN PARR/MAGNUM PHOTOS

MARTIN PARR/MAGNUM PHOTOS

desirable and maybe even inevitable. This cheery outlook shines through large parts of the book, when he writes that such an algorithm will "speed poverty's decline", that routine jobs "will be automated and replaced by more interesting ones", that the health of our planet will "take a turn for the better", and that our own lives will be "longer, happier and more productive".

Domingos has few doubts, and those he has mainly concern whether the technology will really happen as promised. "Maybe," he muses, "the master algorithm will take its place among the great chimeras, alongside the philosopher's stone and the perpetual motion machine."

But what about the future that lies in store for us, should machine learning take over our lives (if it hasn't already)? Again, Domingos sees it all as a positive. "Someday there'll be a robot in every house, doing the dishes, making the beds, even looking after the children while the parents work. How soon depends on how hard finding the Master Algorithm turns out to be."

The implications of machine learning for war and politics may be the most far-reaching of the transformations in store for our world. One reason that Barack Obama defeated Mitt Romney in the 2012 US presidential election is that his campaign embraced machine learning. In the future, "elected officials will be able to ask voters what they want a thousand times a day and act accordingly", writes Domingos. This might work if elected officials always had their constituents' good in mind. But could they not subvert the technology to manipulate the electorate?

"Depending on your world view, a master algorithm is either really thrilling or downright scary"

As for war, the scenario is

Once machines do all the work, will we be at leisure or in despair?

scarier. One can envisage fighting robots that use machine learning to get better and better at killing. Eventually, people will be off the battlefield and robots will fight it out among themselves – and this will prevent human casualties and hence suffering, says Domingos. But surely, all that would do is shift the suffering to other realms of life, not eliminate it?

It's hard to avoid the feeling that machine learning is only going to increase the rift between the haves and the have-nots, as we enter a new phase of survival of the fittest. As Domingos writes, "He who learns fastest wins", and machine learning "is the latest chapter in the arms race of life on Earth".

But he's still not worried. As machine learning does away with most jobs, the world Domingos envisions consists of a large class of unemployed people living on a permanent basic income doled out by the government, while those in the few remaining human occupations will be stupendously wealthy. "For those of us not working, life will not be meaningless, any more than life on a tropical island where nature's bounty meets all needs is meaningless."

Despite my reservations about the value of lives ruled by algorithms, I found the book oddly compelling. Domingos writes with verve and passion, and the book has a strong narrative. This can stall because of lengthy, fairly technical descriptions of the various learning algorithms, such as neural or Bayesian. Reading about their innards can be hard work, even for a former software engineer like me.

But these interludes aside, the book manages to build up a sense of anticipation as we join Domingos and his ilk in their pursuit of the ultimate learning algorithm. He makes you want to know whether they will succeed.

Domingos also provides an insider's view, and doesn't hold back from dishing out delicious titbits on big names in the field. "If the history of machine learning were a Hollywood movie," he says, "the villain would be Marvin Minsky." That's because Minsky, a really stellar name, was deeply sceptical about machine learning, Domingos explains.

The Master Algorithm is a very thorough account of its subject, but I kept thinking that there is another book hidden inside: one that eschews much of the technical stuff and tackles the extraordinary consequences in more depth. That book would build a broader picture for lay readers, to prepare them for what lies ahead. If Domingos's work provokes someone to write such a book, then it will have done us all a great service. ■

Anil Ananthaswamy is a consultant for *New Scientist*

Winning ways

Can science only win book prizes if it dons other clothes, asks **Sumit Paul-Choudhury**

WHY doesn't science win mainstream book prizes? No straight science book has won the Samuel Johnson Prize for Non-Fiction, often called the UK's most prestigious non-fiction award, in its 17-year history. Why?

Is it because writing original, clear and readable science books is hard? Or perhaps publishers are reluctant to submit them to a competition that has in the past leaned heavily towards history and biography? Then again, maybe there is a lack of science advocates among the prize's jury?

Things have changed a little in recent years: with greater science representation on the panel, the field has fared noticeably better. As one of the five judges this year, I was hopeful this trend might continue, that we might even see science take the £20,000 prize.

"One of the joys of reading so many books was being reminded that science touches all of human life"

At it turned out, the list of books submitted for consideration was light on science. Many touched on scientific subjects, from anatomy to cosmology, and there was a notable amount of nature writing, but few had theory or discovery as their central concern. Even fewer focused on technology – a striking deficiency given the social upheaval it is causing.

The overall quality was high, nonetheless, and the longlist included *The Planet Remade: How geoengineering could change the world,* Oliver Morton's thoughtful look at the challenges of geoengineering. There was also a spot for Laurence Scott's lyrical exploration of living online, *The Four-Dimensional Human: Ways of being in the digital world* (*New Scientist*, 9 May), and for Steve Silberman's powerful study of the medical and social history of autism, *Neurotribes: The legacy of autism and how to think smarter about people who think differently* (*New Scientist,* 10 October). Both Scott and Silberman made it onto the shortlist of six, too.

But the story is more nuanced. Science made itself felt elsewhere on the longlist. *Black Earth: The Holocaust as history and warning* by Timothy Snyder is framed by revelatory chapters about the ecological foundations of Hitler's world view, and the potential for history to repeat itself as climate change sets in. And *Landmarks,* Robert Macfarlane's beautiful wilderness gazetteer, is a fusion of geology and nature with the vanishing language that describes them (*New Scientist,* 28 March). Both books enriched my reading of Jonathan Bate's *Ted Hughes: The unauthorised life*, about the poet whose work combined nature and nihilism – a more traditional shortlistee.

And other threads of science ran through the books – the influence of Freud, for example. Indeed, one of the joys of reading dozens of highly diverse books for the prize was being reminded that science and technology touch every sphere of human life, and that the branches of knowledge and culture all, in reality, flow together in one continuous stream.

Science or not, whichever book triumphs on 2 November will be a worthy winner. We will tweet the results on @CultureLabNS. ■

Sumit Paul-Choudhury is editor of *New Scientist*

East Coast Office
225 Wyman Street
Waltham, MA 02451
Email NSSales@NewScientist.com
Phone 781 734 8770

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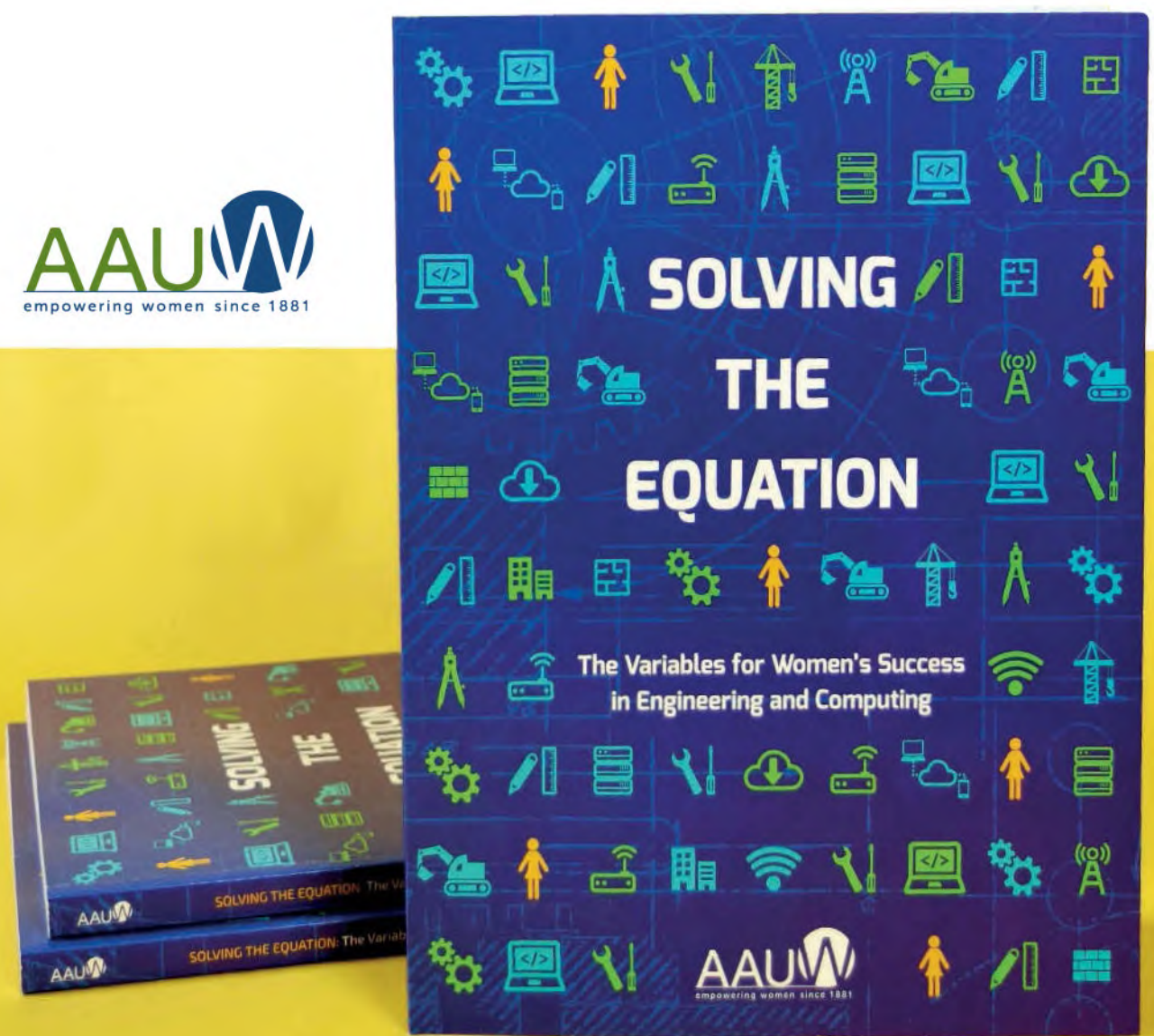

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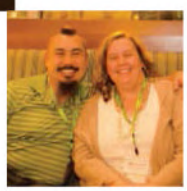

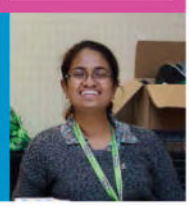

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EDITOR'S PICK

Morality needs more thought

From Anthony Richardson

Dan Jones discusses ways to make people moral (26 September, p 36) and Christian B. Miller asks whether "character education" works (p 26). In part, dilemmas on morality come from a lack of understanding that moral behaviour requires thought. "Moral instruction" is an oxymoron promoted by religious and other groups seeking power and conformity, and doesn't lead to moral behaviour, simply acquiescence or worse.

Our progress has been hampered by a lack of planned education in the area. In the UK, this hasn't been helped by a lack of strategic planning in the National Curriculum. Pupils should be given the opportunity to see how their instinctive reactions and behaviours are based on priorities which served us well a million years ago.

These reactions originate in deep-seated parts of our brain, and often do not serve us well today. It is correct to say that moral behaviour must be based on an understanding of this, together with an exploration of how we think through how we make good decisions for ourselves and others.

Ironbridge, Shropshire, UK

To read more letters, visit newscientist.com/letters

Shining a light on ancient caving

From Donald McCoy

The large collection of *Homo naledi* fossils found deep inside a cave system in South Africa appears to have been placed there intentionally, suggesting some type of ritual for disposing of the dead (12 September, p 8). That raises an interesting question.

How did this ancient hominin, with a brain half the size of ours, navigate caves that are clearly dangerous in pitch blackness while carrying a dead relative? Surely they must also have mastered the making of fire torches – a skill usually attributed to much later development of the human species.

West Lakes, South Australia

Memory recovery and therapy

From Bernice Andrews, Emeritus Professor (Psychology), Royal Holloway University of London

Discussing the issues of "lost" memories and therapy, you report me saying that memories that re-emerge spontaneously are more likely to be real than those from recovered-memory therapy (10 October, p 8). To put the record straight, I did not use the term "recovered-memory therapy" and would never do so. It is a term with no specific definition, often used indiscriminately to describe any therapy (appropriate or otherwise) that might have preceded memories of abuse.

In my role as an expert witness in the courts I recognise that recovering a memory in therapy per se does not necessarily render it unreliable, and the majority of therapists do not use inappropriate practices. In legal cases it is necessary to weigh up a variety of factors that might increase or decrease the likelihood of a memory being reliable before giving an opinion. It is important that experts ground the testimony they provide in scientific evidence rather than opinion, whether they are representing the prosecution or the defence.

For the avoidance of doubt, I do not believe that memories recovered in all forms of therapy are less likely to be real, because there is no consistent scientific evidence to support such a claim. It is, however, universally recognised that certain therapeutic techniques such as hypnosis may be risky if used inappropriately.

London, UK

The measure of the class and the nation

From Bernadette Waugh

It is intriguing to read of the lengths to which scientists go to obtain accurate measurements as, for example, in measuring the Boltzman constant to one part per million (3 October, p 38).

My field is educational measurement. Schools and universities, when marking, for example, a physics exam, don't even use an agreed unit. Teachers and professors just have a group of questions on their topic, allocate some marks and add the marks to produce a percentage non-linear score. Sometimes they even add these non-linear scores (like an assignment) to other non-linear scores (like a semester test) to obtain a composite non-linear score, not mentioning any errors.

The errors in these scores would probably be 5 to 10 in 100 and maybe more. Nobody knows because nobody tests for these errors. Here in Perth it is common for the Curriculum and Standards Authority to report subject examination scores to two decimal places – an accuracy they cannot possibly meet with non-linear percentage scores.

Perth, Western Australia

From Shelley Charik

Your leader on metrology rightly emphasised its importance as a fundamental, though little-regarded, infra-technology (3 October, p 5). The UK has long been a world leader in metrology.

So why is the National Physical Laboratory's watt balance in Canada? Why is work on the Planck constant being done there and in the US, France, Switzerland, New Zealand and South Korea, instead of at the NPL in Teddington, Middlesex?

Could it be because UK government funding for metrology is now £15 million less in real terms than it was a decade ago? In the government's current spending review, ministers are demanding "proof", through econometric modelling, that science funding increases prosperity, while competitor nations continue to outspend us. I imagine the minister responsible watching a son parading with a marching band and proudly exclaiming: "There's my boy, the only one in step."

London, UK

Glass myth needed to be smashed

From Val Sigstedt

Stained glass craftspeople thank Gilead Amit for busting forever the hoary myth that the ancient glass found thicker at lower edges of leaded glass tesserae "proved" that glass is "a super-cooled liquid," and slumps at ordinary temperatures (5 September, p 30).

Medieval glaziers deliberately used variations in their hand-blown glass to put functional, water-shedding "shelves" at the lower edges of individual pieces of stained glass. Like shingles on a roof, these optimised the working life of their lead, putty and glass constructions which, before protective glazing was invented, had to face corroding rain.

Point Pleasant, Pennsylvania, US

"Listening then developing legislation is better than what we are stuck with in the UK"

Maureesa Walsh welcomes, perhaps wistfully, the science policy of Canada's new government (24 October, p 6)

An Ig Nobel with a practical point

From Bill Corner
David Hue and colleagues won an Ig Nobel prize this year for finding that urination takes about 21 seconds in most mammals (Feedback, 26 September). Should this be supported by follow-up studies, it could prove an invaluable early medical diagnostic for men.

If they find that the time required for them to empty a full bladder is significantly different, it could be a very useful indication that they should visit their doctor for a prostate check. Maybe older men should be advised to keep a watchful eye on this as a matter of routine.
Amersham, Buckinghamshire, UK

How low can we go?

From Guy Cox
You say giraffe vocalisations at 92 hertz are "just within the lower limit of human hearing" (26 September, p 17). In fact this frequency, F#2 in Helmholz notation, is just within the range of the human voice. The lowest note a bass is normally asked to sing is a semitone below this, F2 or 87.3Hz, for example in Sarastro's aria "O Isis and Osiris" in *The Magic Flute*. Human hearing goes way past that. The bottom note of the piano is A0 at 27.5Hz.

Returning to *The Magic Flute*, some productions have animals, including giraffes, appearing during Sarastro's aria. Maybe they could be trained to help out with the bottom F, since many basses have trouble with it?
Sydney, Australia

From Alan Harding
You say that frequencies below about 20 hertz are "too low for us to hear" (12 September, p 36). Below these frequencies we don't hear a single musical note; instead we hear the individual vibrations. Think of the sound of motor bikes, helicopter blades or pneumatic drills. The 32 foot stops on large organs go down to around 16 hertz, and even the lowest notes are clearly audible. Indeed, a 32 foot reed is often the loudest stop on the organ: hugely expensive, so only the largest cathedral and concert organs have them. More than anything it is the throb of the 32 foot reed that makes the sound of an organ at full power so thrilling.
London, UK

From Malcolm Shute
Given the discussion of the effects of our sonic environment on health, what a pity that Europe's standard mains frequency is somewhere around a G on the musical scale (or Bb in the US), instead of a more healthy A. Perhaps we would have tolerated the mains hum better, and maybe even have actively sought it.
La Tour d'Aigues, France

Nutrition versus stewed tradition

From Peter Ashby
Chloe Lambert discusses how the nutritional content of vegetables has changed (17 October, p 32). Another change is cooking methods. When I was growing up in the UK in the 1960s vegetables were routinely boiled until they were soft. This destroyed organic nutrients, though the cooking liquids were sometimes reused, preserving some minerals. We eat our cooked veg in a much crunchier state than our parents.
Dundee, Fife, UK

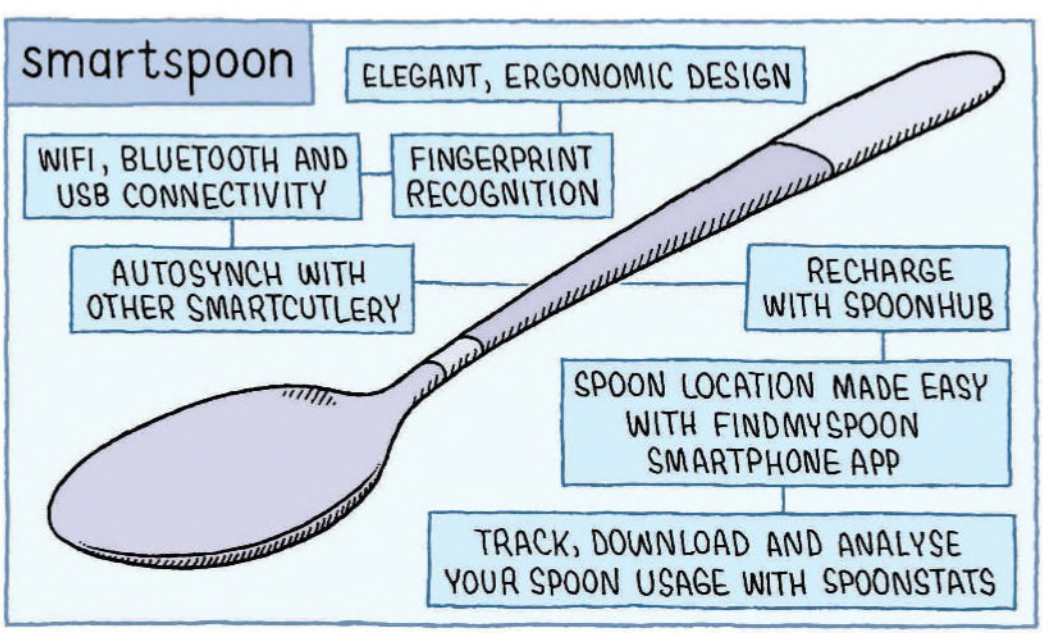
Sakhalin Island is not quite Arctic

From Eric Kvaalen
You quote a spokeswoman for Shell saying: "We already have an operation with the Russian firm, Gazprom, to explore in the Russian Arctic around Sakhalin Island" (3 October, p 7). Sakhalin goes only as far north as 54°N or so, not even close to the 66°N used to define the Arctic circle.
Les Essarts-le-Roi, France

When the hurlyburly's done

From Liz Tucker
Thanks to climate change, trees are now "heading north" (3 October, p 42). Has anyone warned Macbeth?
London, UK

TOM GAULD



For the record

■ **We inverted the figures: of the 47 pairs of twins in Tuck Ngun's epigenetic study, 10 were both gay and 37 differed (17 October, p 12).**

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Speak Now or Forever Lose Your Science

BURROUGHS WELLCOME FUND

The rarefied world of academic science may be what drew many researchers to the scientific endeavor, but remaining isolated from the populace could harm their chosen profession and undermine progress in science and technology.

By all estimates, the public's understanding of science – from basic principles like the scientific process to complicated concepts like string theory – is poor at best. An extreme example of this pervasive problem is Sarah Palin's mockery of fruit fly research during the 2008 campaign trail. In a speech on autism, Palin stated that she and then running mate John McCain would nix projects that "really don't make a whole lot of sense" and have "little or nothing to do with the public good... things like fruit fly research in Paris, France." Little did she know that studies on Drosophila fruit flies have yielded a number of insights into autism and other illnesses, and in fact underpin the whole of modern genetics.

Palin might have an ineffectual grasp of science and technology, or she may be pandering to constituents who feel little connection to science. The average Joe doesn't necessarily appreciate the value of model organisms or the years of research and development that go into making a single drug, two aspects of the scientific endeavor that most researchers take as universal truths. And why should they? Too often scientists are reticent to leave their sphere of learning and investigation to engage the general public, choosing only to speak out when awakened to the goings-on of the outside world by statements like Palin's or the threat of cuts in federal funding.

No time to be silent

The issues faced by today's researcher amount to more than just mere insults and threats. According to an analysis by the American Association for the Advancement of Science (AAAS), federal spending on research and development plummeted by 16.3 percent from 2010 to 2013. Support for R&D hasn't dropped that fast since the end of the space race in the 1970s. With continued blows like sequestration and government shutdowns, many scientists are spending more time writing and rewriting grants than they are doing the research itself. A popular bumper sticker circulating in San Diego area reads "A 10% payline isn't funding. It is a lottery."

The outlook is bleakest for the youngest scientists, many of whom are reconsidering their choice of profession or looking at opportunities outside the United States. In 1980, close to 18 percent of the scientists holding a coveted NIH-funded RO1 grant were age 36 and under. As the pie of NIH funding has continued to shrink, that number has fallen to about 3 percent. While the U.S. investment in science has flat-lined, other countries have upped their commitment. For example, the Beijing Genomics Institute, only one of many such facilities in China, has more capacity to sequence human genomes than all of the genome centers in the United States combined. As the director of the National Institutes of Health (NIH) Francis Collins noted, funding cuts have left scientists demoralized.

"We're losing what we've already invested in and funding fewer grants," said Collins, speaking at Research!America's 2013 National Health Research Forum. "Which of those would have been the next breakthrough in cancer? Which of those would win the Nobel Prize in another twenty years? We'll never know. To sit here and say this is just how politics works is not okay. We are undertaking a noble enterprise that can make a difference in the health of ourselves and our families. We should be making a lot of noise."

However, trying to insert science into politics can be like trying to mix oil with water. The two disciplines are so incompatible, says John Hardin, Executive Director or the North Carolina Board of Science and Technology, because they take completely different approaches to the way they explain or react to the world. For example, scientists investigating climate change might compile the data and try to figure out if it is happening, and to what extent. Politicians, on the other hand, care less about what the science says and more about what the public thinks about the issue. Science is supposed to be objective and free of values. Politics is authoritative and driven by values. But with the right effort, there can be middle ground.

To read the complete article provided to New Scientist by Burroughs Wellcome Fund visit:

http://jobs.newscientist.com/article/speak-now-or-forever-lose-your-science/

PAUL MCDEVITT

HOW'S this for fruitloopery? We can rot apples with the power of our minds, says a lifestyle coach. Self-described self-improvement guru Nikki Owen claims that focusing negativity on a slice of apple will cause it to decay more quickly than one showered with compliments. The finding received a double-page spread in that august journal of the fringe sciences, the *Daily Mail*.

This is, inevitably, an extension of the curious theories of Masaru Emoto, the Japanese researcher who claimed that attaching emotive labels to saucers of freezing water could influence the shape of the ice crystals.

Naturally, the fact that human flesh and apples both contain water means the effect should translate, or in Owen's words: "An apple is a tiny human I can experiment on." You can watch Owen do just that online, berating an apple like the drill instructor of a fruity boot camp.

Quizzed by the *Daily Mail* on the science behind the fruitloopery, Owen cheerfully admitted "there isn't any", before concluding, somewhat counter-intuitively, that "the proof is that it works". Feedback can only put the "hundreds" of successful replications claimed by her followers down to good old cherry-picking.

OUR dowsing rods continue to point us towards "*afuncts*" – items rendered useless by their overwrought design (17 October).

The Ooho is billed as an "edible water bottle", and resembles a small, liquid-filled plastic bag – although the plastic is actually a blend of brown algae and calcium chloride. Delicious.

All very clever, except that soft jelly is fairly useless as a water bottle. The small, fragile capsules are almost impossible to drink from without spilling. The Ooho can't be resealed or reused after opening, like a normal water bottle. And the water must be frozen before it is coated with alginate, so the oil you save on plastic can be burned for electricity instead.

In all, a costly and impractical way to deliver water. Strange then that the Ooho just won a grant worth €20,000 – in a European Union competition designed to foster new, more sustainable products.

Stealing the limelight this week: the larval cover star of *Biology Letters*, featured in a paper titled: "I'm sexy and I glow it: female ornamentation in a nocturnal capital breeder".

IS BLOOD thicker than ink? That is the question prompted by a dispute between two British men both claiming to be the true heir to the baronetcy of the Pringle of Stichill.

The Telegraph reports that Simon Pringle, son of the 10th baronet, was the sole contender until an amateur genealogist uncovered DNA evidence that his father was only distantly related to the rest of the Pringle clan – prompting pure-blooded accountant Murray Pringle to lodge his claim.

The Judicial Committee of the Privy Council must now rule on whether DNA can be used as evidence in a dispute over a hereditary title – surely akin to asking if the presence of stool can clarify whether bears crap in the woods. Of course, a ruling in favour of Murray could uncover innumerable cuckoo's eggs in Britain's noble houses. Are the UK's aristocrats born or made? Watch this space.

SEVERAL readers offered solutions to the brain-teaser posed in Tom Gauld's cartoon (17 October, p 53), but Hillary Kerner's really floats our boat.

Her three-part solution is as follows. Firstly, the Scientist can convince the Businessman to lock the theory in his briefcase, then distract him with something shiny to encourage him to enter the boat and leave his briefcase behind. Once safely on the other bank, she should apologise profusely and then go back for the locked briefcase and the Student.

Alternatively, we are told, the Scientist could throw the theory into the river to protect the Student, because a backup copy is most likely saved on her office computer at the university.

"Otherwise, the Scientist could hypnotise the Businessman into thinking he is a duck," Hillary concludes. "This doesn't solve the problem, but at least provides amusement for the Scientist and Student."

FEEDBACK previously examined the benefits of short and humorous paper titles. Brian Horton supplies both in "Pygmies and Civil Servants", a study published by Conor Ryan in *Advances in Genetic Programming*.

The paper describes a method of finding better solutions to a problem by using an algorithm to "mate" competing answers in succession over many generations.

On the provenance of the title, Brian explains: Civil servant solutions are as exact as possible regardless of their length or complexity; pygmy solutions are short, and being correct is only of secondary interest. By combining the two philosophies, the algorithm eventually approximates a solution that is both simple and correct.

LAST week, Feedback revealed the existence of facial recognition systems for dogs (24 October).

Alan Oliver sends news from South Australia that may throw a confounding factor into the mix.

A possibly mis-typed headline in *The Times* of Victor Harbor announces a "Crack down on Victor's rouge dogs". Reportedly the problem pets make it "extremely difficult for a lost dog to be reunited with its owner".

Who exactly is handing out blusher to these pets, and for what purpose, remains a mystery.

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

Perfect perch

Birds perch standing up, bats upside down. Are there any bird or bat exceptions to this? And why do the two perch differently?

There is a misconception that bats can't take off from an upright position owing to their small leg bones and muscles, which have been reduced to make flight more efficient.

However, flapping their tail membrane allows bats to launch upwards. Granted, such an ungainly take-off would make them vulnerable to predation if they nested on the ground, which makes dropping into flight from a perch a better strategy.

It's not just risk of predation that explains the difference, though. Bats also have superior aerobatic ability. These animals can invert and come to a virtual standstill in flight, which allows them to grasp a suitable roosting position from underneath. This means bats can monopolise the ceilings of caves and other inaccessible roosting sites.

Bats are more manoeuvrable because their wings are larger relative to their body mass than is the case for birds. In addition, though wings have evolved from arms in both cases, the bone is limited to the front edge of a bird's wing whereas in bats the fingers extend across and to the rear edge of the wing, giving bats finer control of the wing surface.

Conversely, birds' lack of manoeuvrability might limit them to more accessible roosts. And this may help explain why birds don't sleep as we understand the term – they rest each side of the brain in turn so that they stay alert to predators and possibly to avoid falling off their perches. However, there are a few birds, including the vernal hanging parrot (*Loriculus vernalis*), that roost upside down in trees.

"Tendons in bats and birds close the claws and lock the feet to the perch when they are relaxed"

The tendons in bats' and birds' feet are arranged to close the claws and lock the feet to the perch when the creature is relaxed, minimising energy expenditure. If a bat dies in its sleep, it doesn't automatically fall to the ground, and needs to be knocked off its perch.

Mike Follows
Sutton Coldfield,
West Midlands, UK

Cottoning on

Why do we prefer to use cotton for our clothing – a water hungry crop – and not synthetic fibres? Is it for particular characteristics that synthetics still do not have?

We love cotton clothing because it is comfortable, soft and easy to clean. Cotton is comfortable as it has a high amount of moisture regain, generally about 7 to 7.5 per cent. Moisture regain is the amount of moisture that the fibre will absorb, expressed as a percentage, starting from a bone dry condition when placed in an atmosphere of standard temperature and humidity. This means cotton can absorb our body moisture and give us the sensation of being cool. In contrast, polyester, a synthetic that many fabrics are made from today, only has a moisture regain of 0.4 per cent and will feel hot, sticky and clammy, especially when the humidity is rather high.

Cotton feels soft because it has a ribbon cross-sectional shape and as a result will bend easily when pressure is applied. Most synthetic fibres have a circular cross section and tend to be stiff because of their low elasticity. In the last 20 years, methods have been developed that enable the manufacture of fibres that are very fine in diameter, and as a result many synthetics now also feel rather soft.

Cotton fabrics are also easier to clean. When our clothing becomes soiled, most people wash them with soap and water. Cotton is alkali resistant and therefore soap doesn't damage the fibre. In addition, cotton is stronger when it is wet, and so cotton clothing will resist being damaged by the agitation of the washing machine.

Most important is the fact that cotton cleans well when washed. Polyester and olefin fibres tend to absorb our body oils and other oil-borne stains which are difficult to wash out. Cotton doesn't readily become stained with our body oils and therefore will tend to remain cleaner.

J. Robert Wagner
Plymouth Meeting,
Pennsylvania, US

This week's questions

ABOVE BOARD
Does wood from the upper part of a horizontal tree branch, which is under tension, have different characteristics to that from the lower part, which is under compression? Is wood ever selected for a purpose on the basis of such differences?
Ross Kinneir
Bristol, UK

ATOMIC BONDS
On an atomic level, how do Post-It notes stick to things?
Felix Barbour
London, UK

LITTLE GREEN ROCKS
We often hear in the news about the results of analysis of meteorites that have arrived here from Mars. How do we know that the rocks are actually from Mars?
Neil Ayre
Kalgoorlie, Western Australia

EIGHT-LEGGED SHRIEK
Do spiders make any vocal sounds? My arachnophobia means that my wife has to eject them from the house, and she claims that some of the bigger ones have "hissed" at her when disturbed.
Joe Roberts
St Austell, Cornwall, UK

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